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ORIGINAL ARTICLES.

I.—The Volcanoes of Barren Island and Narcondam in the Bay of Bengal.

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Third Notice.[1]

(PLATE XIII.)

ALTHOUGH it is now nearly twelve years since I left India, my interest has not abated in the scenes and subjects of former labours in that country, and I am still careful to note anything which is published in reference to them. This practice enabled me to add some facts to the history of the two above-named volcanoes in my *Second Notice*, besides quoting from the account by Mr. F. R. Mallet, the principal results of his survey made in conjunction with Captain Hobday, eleven years after my visit to them, which took place in the year 1873.

It has always seemed to me to be somewhat unfortunate that no adequate representation of the peculiar forms of the crater and cone of Barren Island has hitherto been published; and, as a consequence, the resemblance which this volcano bears to some of those on our satellite the Moon, though referred to, has never been effectively portrayed. In order to obtain such a representation I have had recourse to a device, the result of which will, I think, be admitted to be more satisfactory than the ideal sketches, from a bird's-eye point of view, which have been published.

Two or three years ago I had a model of the island constructed on the scale of 20 inches to a mile from data given in Mr. Mallet's paper. This model has since been photographed, and by combining the negative with suitable sea and sky negatives, the picture now reproduced has been arrived at.

Of course, on strictly artistic grounds, objection might be raised to the method which has been adopted; but as this pictorial diagram represents with close approach to accuracy the appearance of the island as it might be seen from a balloon, it subserves in a very special degree the main object aimed at, and will, I trust, prove acceptable to all interested in volcanic phenomena, whether terrestrial or otherwise. Possibly too, the above description of the method

[1] First Notice, Geol. Mag. Vol. VI. 1879, pp. 16–27. Second Notice, Geol. Mag. Dec. III. Vol. V. 1888, No. IX. p. 404.

View of Barren Island—Bay of Bengal.

which has been followed may suggest to others, who may not have tried it, a graphic means of illustrating geological structure of more or less analogous character.

Notes on the Fauna.

Some few remarks on the fauna of these Oceanic islands, as they may be called, with special reference to the light thrown by it on the question of their antiquity, may, perhaps, be suitably added here, especially as the subject has not been alluded to in my previous communications.

While the volcano now called Narcondam is absolutely extinct and there is no historical record of its having ever been in a state of activity, the volcano forming Barren Island is only in a quiescent stage and towards the end of the last century and the beginning of this it appears, as has been described on previous pages, to have been in such a condition of disturbance that all the animal and vegetable life previously existing upon it, was in all probability destroyed.

The characteristics of the faunas of both islands, so far as they are at present known, support these conclusions. The animals found on both are immigrants; they consist chiefly of birds and insects. Some of them are no doubt voluntary visitors such as the raptorial birds, pigeons of strong flight, and aquatic species. There is, however, one important species found on Narcondam only, which testifies to long continued quiescence on that island.

It is a hornbill, of which, when we landed on the island in 1873, two specimens were obtained and they proved to belong to a species previously unknown.[1]

As there are no hornbills in the Andaman or Nicobar Groups, the progenitors of this species must have arrived from some far distant region in Indo-China, or possibly in the Malayan Archipelago; and their descendants have since developed the specific characters which serve to characterize the species. This fact may alone be taken to indicate a long period of time, during which the island was, moreover, probably not devastated by fire.

On the cliffs of Narcondam, in quite inaccessible positions, there were nests of *Collocalia*, or rock swiftlets, specimens of which I obtained by shooting, and they proved to consist of seaweed agglutinated by mucilage, and quite different from the true edible nests, which were thus proved to be the work of a distinct species.

As for Mammals and Reptiles there is little to be said; the former are represented on Narcondam by a local variety (?) of very dark colour, of *Pteropus*, or Flying Fox, which may have been first carried thither by the wind. On both islands rats are found, *Mus Andamanensis* which, possibly, like the few reptiles, namely, *Hydrosaurus* and Skinks, may have arrived on drift timber.

In general it may be said that the character of the Vertebrate fauna indicates its own derivation, through the influence of the S.W. Monsoon, from the Andaman Islands, which are about 90 miles

[1] *Rhyticiros Narcondami*, Hume.

distant, and it would seem that the insects which have been collected of late years point to the same conclusion.

The attempts which have been made from time to time to naturalize goats and fowl on these islands with the charitable object of affording food to those who may be shipwrecked there, has been unsuccessful, owing possibly to the absence of a perennial supply of fresh water on Narcondam and the brackish character of the hot spring on Barren Island.

I have not as yet seen a promised account of the flora of these Islands by Dr. Prince. Doubtless it deals or will deal with evidence similar to that afforded by the fauna.

II.—On the British Earthquakes of 1892.

By Charles Davison, M.A.,
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During the past year a comparatively large number of earthquakes have been felt in Great Britain, the most notable being those which originated within a short distance from Pembroke, between the 17th and 22nd August. This series will form the subject of a separate memoir. In the present paper are given a list of the earthquakes of 1892, complete so far as I can make it, with descriptions of three important shocks felt in the parish of Loch Broom (Ross-shire) on March 4, and in south-west Cornwall on May 16 and 17.

It is my pleasant duty to express my obligations and to offer my hearty thanks to the numerous observers who have assisted me in my work. Many of the accounts which they have communicated are of great interest and value, and I much regret that it is impossible to insert them all here. It was necessary to make some selection, and those only are given which, from various circumstances, happen to throw most light on the origin of the shocks. Every note, however, has been considered, and has been of some service in writing these descriptions; and I trust that, if any of my correspondents should happen to see these pages, they will not think their kindness and trouble have been thrown away if their own reports do not appear in full. May I also add how grateful I should be for notice—especially early notice—of any earthquake, whether real or only suspected to be such? The completeness of the seismic record in a given district is of the first importance; and, if Great Britain forms a region in which shocks are slight and somewhat rare, there are yet parts of it whose seismic history would help towards the solution of several geological problems.

As in previous papers,[1] the hours are numbered from 0 to 24; the time being Greenwich mean time. The intensity is estimated in

[1] On the British Earthquakes of 1889, Geol. Mag. Dec. III. Vol. VIII. 1891, pp. 57–67, 306–317, 364–372. On the Inverness Earthquakes of November 15 to December 14, 1890, Quart. Journ. Geol. Soc. vol. xlvii. 1891, pp. 618–632. On the British Earthquakes of 1890, with the exception of those felt in the neighbourhood of Inverness, Geol. Mag. Dec. III. Vol. VIII. 1891, pp. 450–455. Record of Observations on the Inverness Earthquake of November 15, 1890, Birmingham Phil. Soc. Proc. vol. viii. 1891. On the British Earthquakes of 1891, Geol. Mag. Dec. III. Vol. IX. 1892, pp. 299–305.

terms of the Rossi-Forel scale.[1] The epicentrum is really an area, the projection of the seismic focus or centrum on the earth's surface. As, however, I have no means of determining the form of this area, I have given instead, the position of the point vertically, or nearly so, above the centre of intensity of the focus.

On the maps, the position of the epicentral point is indicated by a star. Places where the shock was felt is indicated by small black discs; those where it was not felt (by several or many persons) by small circles. A cross drawn through a disc or circle indicates that the usual earthquake-sound was also heard there; a cross alone, that the sound was the only phenomenon recorded, but not necessarily implying that the shock was not also felt.

List of Earthquakes in 1892.

In the following list, only those shocks are recorded that were felt by at least two observers. For the notes relating to those at Invergarry and Ardochy, I am again indebted to Mr. John Grant and Mr. Murdoch Matheson, who have continued their valuable work of recording the earthquakes of that part of Inverness-shire. Mr. Matheson informs me that all the Ardochy shocks were felt by at least four persons.

Feb. 29, 22h. 35m., Ardochy. A slight shock, accompanied by a low rumbling noise: duration of sound, 40 seconds.
„ 23h. 15m., Ardochy. Duration of shock, about 15 seconds: intensity, IV.; preceded by a low rumbling noise.
Mar. 4, about 7h. 30m., Loch Broom.
Apr. 3, 7h. 35m., Ardochy. A slight shock like the passing of a carriage.
May 16, about 22h. 30m., South-west Cornwall.
„ 17, about 1h. 30m., „ „
Aug. 17, about 23h. 30m., Pembrokeshire. A slight shock.
„ 18, 0h. 23m., South-west of Pembrokeshire. A sound like distant thunder heard.
„ „ 0h. 25m. Principal earthquake (intensity, nearly VIII.), felt most strongly in Pembrokeshire, but perceptible throughout nearly all Wales, in the west and south-west of England and the south-east of Ireland; disturbing at least 26 counties.
„ „ 0h. 37m., Pembrokeshire.
„ „ about 1h. 5m., Pembrokeshire. A very slight shock.
„ „ about 1h. 40m., Pembrokeshire and adjoining counties, Devonshire and Wexford. The strongest shock but one of the whole series.
„ „ about 2h. 40m., Pembrokeshire.
„ „ about 4h., South-west of Pembrokeshire. A slight shock.
„ 22, about 11h. 55m., Pembrokeshire.
Sep. 25, 8h. 13m., Invergarry. A rumbling noise, lasting about 1 sec.

[1] A translation of the Rossi-Forel scale of seismic intensity is given in the Geol. Mag. Dec. III. Vol. VIII. p. 58; Nature, vol. xlii. 1890, p. 349.

Oct. 24, 10h. 10m., Ardochy. Duration of shock, several seconds; intensity, IV.; preceded, accompanied, and followed by three distinct rumbling noises, of which the first was the loudest.

Nov. 18, 2h. 17m. or 14h. 17m., Ardochy. A slight shock, followed by a slight rumbling noise.

The following are recorded by only one observer: (1) Aug. 19, 9h. 30m., St. David's (Pembrokeshire); a rumbling noise heard, without any accompanying vibration. (2) Aug. 23, 4h. 30m., Pembroke Dock; a shock of intensity, IV. (3) Sept. 11, at or some time after 1h. 23m. (the observer's watch had stopped at this time), Watertown near Northam (North Devon); three successive very slight impulses, accompanied by a rolling sound, apparently at a great distance below but to the south-west. I am indebted for this record to Mr. T. Mann Jones, F.G.S.

Loch Broom Earthquake: March 4, 1892.

Time of occurrence, about 7h. 30m. Intensity, V. Epicentrum, 6 miles N. 26° W. of Ullapool, *i.e.* in lat. 57° 58′ 30″ N., long. 5° 13′ 30″ W.

Disturbed Area and Intensity.—I have received 37 records[1] of this earthquake from 33 different places. Most of these places are close to the sea, but the coast in this part of Ross-shire is much indented, and the data are sufficient for determining the boundary of the disturbed area, though no doubt somewhat roughly. Besides these definite records, I am informed by Mr. R. MacRae that both shock and sound were noticed to the extreme end of the peninsula of Coigach; and by Mr. A. McKenzie that the shock was felt on the south side of Little Loch Broom.

The intensity of the shock was V. at Isle Martin; and IV. at Achduart, Achiltibuie, Achnahaird, Achninver, Ardindrean, Badinscally, Badintarbet, Culcraig, Inverlaal, Isle Tanera, Kildonnan, Leckmelm, Lochinver, Morefield, Polglass, Scorraig, Scot Rae, Strathmore, and Ullapool.

The boundary of the disturbed area corresponds to an isoseismal of intensity IV. This line includes an area 28 miles long and 17 miles broad, and contains about 364 square miles, its centre being at a point 6 miles N. 26° W. of Ullapool. The longer axis is directed approximately N. 30° W. and S. 30° E.

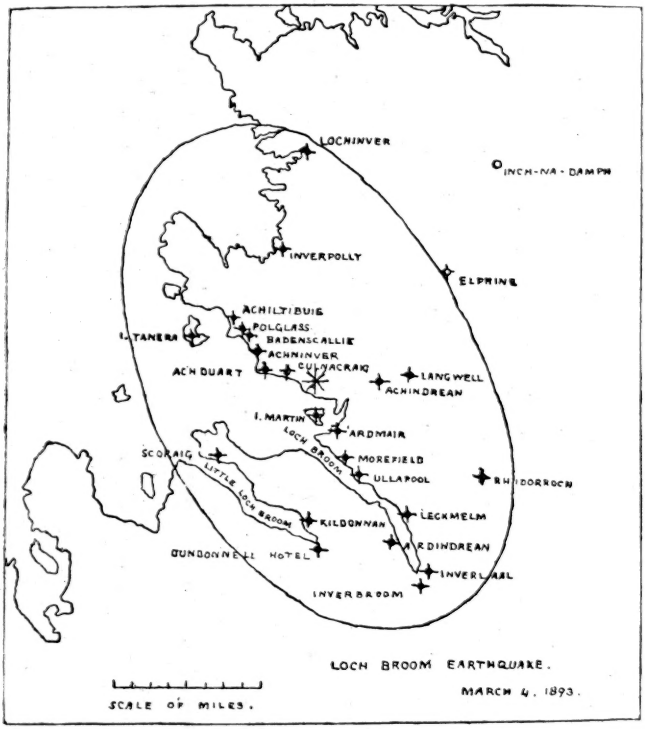
Nature of the Earthquake-Phenomena.—Of the six places from which records are here given, Dundonnell Hotel lies near the head of Little Loch Broom; and the other five are close to the longer axis of the disturbed area.

Inverbroom (Observer, Mr. J. A. Fowler, yr., of Braemore).—The shock like going over two or three small waves in a small boat; duration, three to four seconds. A very loud rumbling, as of a heavy

[1] For several of these records, as well as for their own observations, I am much indebted to the kindness of Mr. D. Fraser and Mr. R. MacRae, of Achiltibuie, Miss E. Lang, of Ardindrean, Mr. M. McKenzie, of Achindrean, Mr. W. Matheson, of Isle Tanera, and Mr. J. S. Stewart, of Isle Martin.

waggon driven rapidly over a granite-paved road, preceded and coincided with the shock.

Ardindrean (Observer, Miss E. Lang).—About five or six vibrations, lasting about three seconds. The sound like that of a carriage passing close by the house, becoming gradually louder and then dying away; both beginning and end coinciding with those of the shock; the principal vibrations felt when the sound was loudest.



Dundonnell Hotel (Observer, Mr. J. A. Whyte).—Without any previous warning, a violent *thud* heard as if some heavy body had fallen in the adjoining room. This was immediately followed by a slight vibrating movement lasting about four or five seconds, during which was heard a very faint booming sound, that died away about a second before the tremor.

Ullapool.—The shock resembled the effect produced by the fall of a heavy body, followed by a rumbling noise that lasted about seven seconds.

Isle Martin (Observer, Mr. J. S. Stewart).—Vertical motion perceptible, first upward and then downward; duration of shock, about six seconds. A rumbling noise heard, resembling at first the boom of a cannon and afterwards distant thunder; the sound followed the shock immediately without intermission.

Achiltibuie.—(1. Observer, Mr. D. Fraser.) One series of vibrations, lasting about three or four seconds. A rumbling sound, beginning like a shot from a gun and dying away like a heavy chain dropping from a ship; the vibrations felt when the sound was loudest; the end of the sound followed that of the shock by about five seconds.—(2. Observer, Mr. R. MacRae.) A tremulous motion, the vibrations too rapid to be counted and all apparently of the same intensity. A rumbling sound like that of a conveyance passing over a gravel road some distance away; the beginning coincided very nearly with that of the shock; the end followed that of the shock by a very short interval.

It will be seen that the disturbed area and the sound-area are approximately coincident. At Elphine, however, which is near the north-east end of the shorter axis of the disturbed area, the shock was not felt, while a rumbling sound was heard by Mr. A. Hunter like that of a gig passing along the road close by. Mr. Hunter was good enough to make several enquiries in the neighbourhood. About one mile nearer Ullapool, the sound, he finds, was heard and no shock felt, but the observer was standing, and in the open air, an unfavourable position for perceiving a slight vibration. At Ledmore, about two miles east of Elphine, neither shock nor sound were perceived. In the absence of detailed records from the south side of Little Loch Broom, it is impossible to say whether the disturbed area and sound-area were, or were not, concentric.

Time-relations of the Shock and Sound.—The beginning of the sound is said to have preceded that of the shock at Inverbroom, Inverlaal, and (by a very short interval) at Morefield; coincided with it at Achiltibuie, Ardindrean and Lochinver; and followed it at Kildonnan and (by a very short interval) at Dundonnell Hotel, Isle Martin and Ullapool.

The end of the sound is said to have preceded that of the shock at Dundonnell Hotel; coincided with it at Ardindrean and Lochinver; and followed it at Achiltibuie.

Origin of the Shock.—The broken character of the country may be answerable to some extent for the elongated form of the disturbed area, and on this account it would be unwise to lay too much stress on the position of the epicentrum and the direction of the longer axis as determined above. Taking them as they stand, however, we should infer that, if the shock were fault-formed, the direction of the fault-line should be N. 30° W. and S. 30° E. The best guide as to the direction of hade is the greater intensity of the shock at Isle Martin than elsewhere; and, this place lying to the south-west of the longer axis, it would follow that the fault must hade towards the south-west; a conclusion supported by the sound being perceived immediately after the shock at Isle Martin, and also, perhaps, by the overlapping of the sound-area in the neighbourhood of Elphine. The fault-line must in that case lie on the north-east side of the axis, parallel to it and distant from it probably about one mile and not more than two or three miles. The length of the seismic focus in a horizontal direction must have been considerable, perhaps several

miles; and the observations on the time-relations of the shock and sound show that the slip must have died out slowly towards the south-east and rapidly towards the north-west. Lastly, the observations at Isle Martin and Inverbroom on the first direction of the vertical motion would seem to indicate that the relative movement of the rock on the downthrow side must have been downwards, that is, that the slip must have increased the throw of the fault and possibly also tended to increase the depth of Loch Broom.

Authorities.—Besides those already mentioned I am indebted to the following observers for accounts of this earthquake: Achduart, Miss M. MacLennan; Inverlaal, Mr. M. M'Lean; Kildonnan, Mr. A. McKenzie; Lochinver, Mr. A. Beveridge; Morefield, Mr. A. Ross; Scorraig, Miss A. Cameron; Ullapool, Rev. J. MacMillan. The account of the shock at Ullapool given above is taken from a paragraph (probably copied) in the "Birmingham Daily Post" for March 7, 1892.

S. W. Cornwall Earthquakes: May 16–17, 1892.

During the night of May 16–17 two distinct earthquakes were felt in south-west Cornwall, the first at about 22h. 30m. on May 16, the second and stronger at about 1h. 30m. on May 17. According to one report (from Porthleven), several shocks of a slighter character were felt in the interval between them; but, this being the only evidence I have been able to obtain, their occurrence must be regarded as doubtful though it is worthy of notice that Porthleven is one of the five places where the principal shock was most severe.

I may refer here to a report printed in several newspapers that, on the afternoon of May 17, the water in Mount's Bay, and especially in Penzance Harbour, was tinged with a decided yellow colour; and this was generally considered, I believe, as a result of the earthquake. But Mr. J. Morrish, Dock and Harbour Master at Penzance, informs me that this discolouration had been noticeable for at least a fortnight previously. Whatever may have been its origin, it cannot therefore, as he observes, have had any connection with the shocks.

First Shock: May 16.

Time of occurrence, about 22h. 30m. Intensity, IV. Epicentrum, about $1\frac{1}{4}$ miles N.E. of Wendron, *i.e.* in lat. 50° 8′ 30″ N., long. 5° 13′ 5″ W.

This shock, being the first and also an exceedingly slight one, was felt or recorded by very few observers. I possess only nine accounts from eight different places, namely, Breage, Budock, Manaccan, Mawgan-in-Meneage, Nancegollen, Perran-ar-Worthal, Porthleven, and St. Stythians. At Breage, the intensity of the shock was IV. and a loud rumbling sound was heard, lasting two or three seconds. At Mawgan-in-Meneage, the noise, which was not so loud as that of the principal shock, seems to have been the only phenomenon observed. From all the other places, the records consist of little more than the statement that a slight shock was felt.

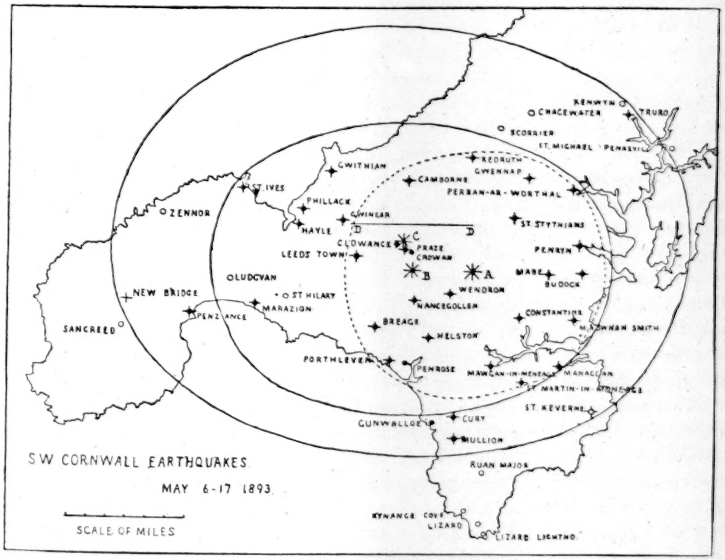
The boundary of the disturbed area is shown on the map by a

dotted line. In form it is roughly circular, but from the north-west quarter there is no evidence of a reliable character. This portion may therefore be incorrectly drawn, but the position of the epicentrum in all probability does not differ greatly from that given above. Assuming the accuracy of this boundary line, the area disturbed must have been about 12½ miles in diameter and have contained about 120 square miles.

Second Shock: May 17.

Time of occurrence, about 1h. 30m. Intensity, nearly V. Epicentrum, 3½ miles N. 15° W. of Helston, *i.e.* in lat. 50° 8′ 30″ N., long. 5° 18′ 0″ W.

Disturbed Area and Intensity.—The following discussion is founded on 70 records from 40 different places. These places are shown on the accompanying map, which, with the exception of the dotted line, refers entirely to this earthquake. For so slight a shock the number of records is unusually great, and this is due to the kindness of several gentlemen who, at the cost of much trouble, made further inquiries within and near the disturbed area. The Rev. Canon Rogers, of Gwennap, has sent me several accounts from that village, from Redruth and other places; accounts which have added very materially to our knowledge of the shock. For six records from Marazion I am indebted to Mr. Fortescue Millett, and for others from the neighbourhood of Hayle to Dr. Cleaver, of Hayle, and the Rev. F. Hockin, of Phillack.



The intensity of the shock was greater than IV. but not quite V. at Helston, Nancegollen, Penrose, Porthleven and Wendron; IV. at

Breage, Budock, Camborne, Gwennap, Gwinear, Gwithian, Hayle, Lannarth, Leedstown, Mabe, Manaccan, Marazion, Mawgan-in-Meneage, Mawnan Swith, Penryn, Perran-ar-Worthal, Phillack, Praze, Redruth and St. Ives; III. at Mullion, Penzance and Truro.

These observations enable us to draw the isoseismal of intensity IV. with some accuracy. The area inclosed by this curve is 20 miles long and 15 miles broad, and contains about 224 square miles. The centre of this area is indicated on the map by the star marked B. The direction of the longer axis is approximately east and west.

Outside this area we have observations from only seven places, and not more than four of these are of much value in determining the boundary of the area over which the earthquake was perceptible. Some guide is however given by the position of several places where the shock was not felt, inquiries having been made from many persons in each place. It is clear that the accuracy of the outer line cannot be depended upon, but it is no doubt sufficiently close to the correct position to support the inferences that will be afterwards made about the origin of the shock. As drawn upon the map, the area enclosed by this line is 29 miles long and 22 miles broad, and, including the part covered by the sea, contains about 480 square miles. The centre of the area is indicated on the map by the star marked C.

Nature of the Earthquake-Phenomena.— Of the accounts given below, the first group come from places lying close to the shorter axis of the disturbed area:—

Helston (Observer, Rev. W. Jeffery).—A distant rumble heard, gradually increasing in intensity until it became a violent thundering sound, at which instant everything in the room was perceptibly shaken, the sound dying away after the shock with the same rumble as before. Duration of shock, two to three seconds.

Redruth.—(1. Observer, Mr. T. Carhart.) Two vibrations, the first the stronger; preceded and followed by tremulous motion; vertical motion perceptible, downward first and then upward. A roaring sound heard, preceding the shock by about five seconds, and ending several seconds after it. Duration of the shock, about four seconds.—(2. Observer, Mr. W. K. Wilton). A continued trembling, consisting of several vibrations, the strongest shortly after the first, then dying away; direction, apparently from the south-west; duration, less than ten seconds. A sound like that of an explosion in a distant part of a mine but more prolonged.

The next three places are close to the longer axis of the disturbed area, the first two near the eastern end:—

Penryn (Observer, Mr. J. Blamey, M.R.C.S.).—Two distinct vibrations of equal intensity, each accompanied and followed, but not preceded, by a tremulous motion. Each vibration also was accompanied by a sound of the same kind and intensity, like the crash of a heavy weight on the floor above, and followed by a rumbling sound like that of a waggon roaring along the street, continuing after the tremulous motion and dying away in the distance. Duration of shock, three or four seconds.

Budock (Observer, Mr. R. Mollett, awakened by the earthquake).—The sound like that of an explosion at some distance, followed by a distant rumbling sound lasting about 30 seconds.

St. Ives (Observer, Rev. J. Balmer Jones).—A tremulous motion, half felt, half heard, lasting perhaps nearly half a minute; and then, the shock, like the sliding fall of a mass of slates on the roof, but much heavier, lasting less than five seconds, the house left vibrating afterwards. The sound like that of a heavy waggon driven rapidly over a rough granite pavement, or like the rapid approach of a hurricane gust; the beginning preceded that of the principal vibrations by more than 15 seconds; it became gradually louder, the shock coming like a great blow when the roaring sound was at its highest, and then the sound died away like the vibration of a great bell, the end following that of the shock by about 15 seconds.

The above places are all within the isoseismal of intensity IV. Inside this line, the nature of the earthquake, though variable to some extent, may be summed up as follows: a tremulous motion, accompanied by a rumbling sound, increasing in intensity until the principal vibrations and a sudden sound (as of an explosion) were perceived simultaneously, followed by a tremor and sound which gradually died away. At some places, two vibrations, each accompanied by an explosive sound, were observed, as at Redruth and Penryn mentioned above. This was also the case at Breage and Perran-ar-Worthal.

Outside the isoseismal of intensity IV., the sound-phenomena became relatively more prominent, the shock being felt either very slightly or not at all. At St. Keverne, Mr. E. J. Leverton-Spry (who was awakened by the sound) felt no shock, but heard two or three sounds like knocks at the front door. With this very interesting account may be compared the following record from Phillack, a place on the opposite side of the epicentrum but several miles nearer it. The observer was in the open air, standing, and felt no shock, but the sound resembled that of successive discharges of cannon, about six in number and of equal intensity, lasting about three or four seconds. The significance of these observations will be pointed out when discussing the origin of the earthquake.

Time-relations of the Shock and Sound.—These relations have an important bearing on the origin of the shocks, and I endeavoured in my inquiries to direct particular attention to them. Unfortunately, a large proportion of the observers (about one-third) were awakened by the shock, and consequently the initial phenomena were lost to them.

The beginning of the sound is said to have preceded that of the shock at Camborne, Cury, Gwennap, Helston, Manaccan, Mullion, Nancegollen, Porthleven, Redruth, St. Ives, St. Martin and St. Stythians; coincided with it at Marazion, Mawgan-in-Meneage and Penzance; and followed it (immediately) at Gwinear.

The end of the sound is said to have preceded that of the shock at Manaccan; coincided with it at Cury, Lannarth, Marazion, Mawgan-in-Meneage and Penzance; and followed it at Gwennap,

Gwithian, Hayle, Helston, Penryn, Redruth, St. Ives, and St. Stythians.

It will be seen from the map that, all over the disturbed area, the beginning of the sound preceded that of the shock and the end of the sound followed that of the shock, the exceptions occurring chiefly at places at some distance from the epicentrum and where the slighter vibrations would be less perceptible.

Origin of the Shocks.—The disturbed area of the first shock is approximately circular. This, in the case of so slight a shock, shows that its seismic focus was of small dimensions.

The focus of the second shock must have been of some magnitude. This is indicated by its elongated disturbed area, and perhaps also by the long duration of the shock. Assuming it to have been fault-formed, the direction of the fault in the neighbourhood of the epicentrum must be parallel or nearly so to the longer axis of the disturbed area, *i.e.* must be about east and west. The intensity of the shock was greatest at Helston, Nancegollen, Penrose, Porthleven and Wendron, all lying to the south of the longer axis of the disturbed area. Now, the intensity of a shock should be a maximum near the point where the normal to the seismic focus through its centre meets the surface. The fault must therefore hade towards the south, and consequently the fault-line must lie on the north side of the epicentrum. This inference is corroborated by the relation which the outer line bounding the sound-area and the area over which the shock was very slightly felt bears to the isoseismal line of intensity IV. The distance between these two lines is greater on the north side than on the south; and, since the sound-vibrations proceed chiefly from the upper and lateral margins of the slip-area or seismic focus, it follows that the upper margin must be on the north side of the epicentrum; in other words, that the fault hades towards the south. Since the centre (C) of the area bounded by the outer line is vertically above a point within the upper margin of the focus, the line of fault must be a short distance, probably not more than a mile or so, to the north of this point. The line D D on the map represents a probable position of the fault-line, but it may be in error by as much as half a mile either to the north or south.

Having thus ascertained the position and hade of the fault, at any rate approximately, we may now consider the nature of the displacement or fault-slip which produced the earthquakes. In the first place, the line joining the two epicentral points is parallel to the fault-line, and therefore the centres of intensity of the two foci must have been at about the same depth. The horizontal length of the first focus, as we have seen, was probably short. That of the second must have been several miles. We have no means of determining it accurately; but, in a case like this, we cannot be far wrong in taking it as the difference between the lengths of the two axes of the disturbed area. For the isoseismal of intensity IV., this difference is five miles; for the outer line it is seven miles. Again, the estimates of the duration of the shock and sound at Budock and St. Ives, places close to the longer axis of the disturbed

area, show that the length of the seismic focus must be reckoned in miles. This is all that can be said, for estimates of duration are generally too great, and we are ignorant of the velocity of the earth-wave in the case of a slight earthquake. Also the process of slipping may have occupied an appreciable time. But the two classes of evidence do not conflict. For a distance, therefore, of about $2\frac{1}{2}$ miles on either side of the epicentrum B, the slip may have been comparatively great; and then it must have gradually died away in either direction until it became imperceptible. These lateral margins of the focus cannot have been much under a mile in horizontal length, and they were probably more, especially towards the west.

On this point, some important evidence is given by the observations made at Penryn, Budock, St. Ives and other places, especially those near the longer axis of the disturbed area. Though the precursory sound was observed at most places, it is clear that at those near the east end of the area the tremors and sound were chiefly perceived, or perceived for a longer time, *after* the shock; and *before* the shock at places near the west end. This shows that the slip died out more gradually towards the west than towards the east.

It is curious that records of the double vibration, or rather double character, of the second shock, come from only four places, namely, Redruth, Perran-ar-Worthal, Penryn and Breage. I believe, however, that the absence of other records is accidental, for few observers perceive or record changes in the intensity. Now a double shock may be due (1) to the focus consisting of two detached, or practically detached, portions; (2) possibly to the partial reflexion of the earth-wave; or (3) to a repetition of the original impulse. The distribution of the four places mentioned above favours the latter interpretation, the first vibration being slightly more intense than the second. It is clear, too, from the observations recorded at St. Keverne and Phillack, that the amount of slip varied somewhat irregularly over the focus, giving rise to several maxima of sound-intensity, the feebler sound between the maxima not being perceptible to the observers at these places.

Lastly, the simple character of the shock renders observations on the first direction of the vertical motion more reliable than usual. At Redruth, on the upthrow side of the fault, the movement is said to have been first downward and then upward. At Manaccan, on the downthrow side, it was first upward and then downward, and this, I am informed by the Rev. A. R. Eager, D.D., is attested by the evidence of several observers. This shows that the slip of the downthrow side must have been relatively downwards, thus increasing the throw of the fault.

We may now sum up as follows. For some time the strain along this fault had been increasing. Either, however, the strain or the resistance to it was not equally distributed, and first a slight slip took place at 10·30 p.m. on May 16. This had the effect of equalising the strain or the resistance to it, and, consequently, three hours later, a second and double slip took place over a much greater

length of fault to the westward, the slip-area reaching to, and perhaps including, that of the first shock; its eastern lateral margin being shorter than the western owing to that shock having previously relieved the strain.

I am not aware that any fault has been traced by purely geological evidence in the position indicated above. But I have little doubt as to its existence there. Moreover, the direction and hade of the suggested fault are in accordance with the known geological structure of the district. It would seem indeed that these shocks are indices of the latest of the long series of movements that have produced the English Channel.

Authorities.—Six of the records on which the preceding account is founded are taken from the "Falmouth and Penryn Times" for May 21, and I am indebted to the courtesy of the Editors of this newspaper and also of the "Western Morning News" (Plymouth) for inserting letters from me asking for observations on the shocks. For other records I have to thank: Breage, Mrs. Nicholas; Budock, Mr. R. L. Mollett; Constantine, Mr. J. V. Albert, M.R.C.S.; Cury, Mrs. J. Bowden; Gwithian, Mr. W. T. Richards; Gwennap, Rev. Canon Rogers; Gwinear, Rev. A. J. Perry; Hayle, Mr. W. F. Cleaver and Mr. J. Vivian; Helston, Rev. W. J. Jeffery and Mrs. Tyacke; Lannarth, Mrs. Shaw; Mabe, Mr. J. E. James; Manaccan, Rev. A. R. Eager, D.D., and Mr. W. Smith; Marazion, Mr. F. Millett; Mawgan-in-Meneage, Mrs. Crocker and Rev. H. L. Wright; Mawnan Smith, Mr. W. Borlase; Mullion, Rev. T. H. Scholefield; Nancegollen, Mr. P. B. Hancock; Penryn, Mr. J. Blamey, M.R.C.S.; Penzance, Mr. A. Craig and Mr. J. Morrish; Perran-ar-Worthal, Rev. H. M. Harmer and Mrs. Rudge; Phillack, Rev. F. Hockin; Praze, Mr. W. Pearce; Redruth, Rev. J. W. Lane and Mr. T. Carhart; St. Ives, Rev. J. Balmer Jones, M.A.; St. Keverne, Mr. E. J. Leverton-Spry; St. Stythians, Mrs. Wesley Andrew; Truro, Mr. H. Crowther; Wendron, Rev. F. T. C. Margetts.

III.—The Condition of the Arctic Lands in the so-called Glacial Age.

By Sir Henry H. Howorth, K.C.I.E., M.P., F.R.S., F.G.S.

In my recently published book on the "Glacial Nightmare" I have tried, among other things, to show that the traces of glacial action in the northern hemisphere, instead of being circumpolar, are in fact limited to one half only of the hemisphere, namely, that bounded on the East by the White Sea and on the West by the river Mackenzie. This conclusion is of course not new, and I have merely collected and condensed the evidence of many witnesses to it. I have further suggested as possible, that while Scandinavia, Finland, and the British Islands were the homes of very large and extensive glaciers, the lands now occupying the Polar Sea were in a very different condition, and anything but the homes of widespread ice action.

Before I prosecute the issues further, which you have allowed me

to raise in the GEOLOGICAL MAGAZINE, I should like to devote a short space to this interesting and important subject.

To begin with Iceland, the Mountains of Iceland when free from snow seem to me to unmistakably prove that there never was there what it is most patent there was in Scotland and Norway, namely, a great mass of ice occupying the high ground and polishing and smoothing the surface. The contour of the mountains is ragged and torn and splintered, and in some places, such as Allmanna-Gia, it is cut into the most fantastic shapes with projecting pinnacles.

Again, the many blocks of stone found there on the surface of the rocks are not strangers and true erratics, but are all natives. Again, as Mr. Baring Gould, who has travelled much there and has written a graphic account of the Island, says: There are no traces of moraines there except at the skirts of modern glaciers, and he adds that only in one spot had he found unmistakable glacial grooving, namely, along the hill above Bjarg in Mith fjord, and he points out that what are really the results of the action of flowing water in polishing the surface had been mistaken by some for the action of ice. Thus in describing the so-called heithis or fell lands the same writer says: "'These heithies, being exposed to the action of snow water, are much torn and mangled, the rock being, in many places, quite polished by the streams from the thawed snows, as they slide over them. Mr. Chambers, in passing this same tract of moor from a different direction, saw similar polishings, and at once put them down to glacial action, and the furrows caused by the little rills to the striæ of glacial grooving. I believe him to have been mistaken, for the following reasons: the rock is not smoothed except where the streams flow over it, and a slight node of rock three inches high is quite sufficient to divert the stria and alter the direction of the polished surface. A considerable removal of earth had taken place this spring, and I observed no marks of glacial smoothing on the rock upon which the soil had rested; it was ribbed and curdled like ordinary lava" (Iceland, its Scenes and Sagas, p. 63.)

Again, turning from the mainland of Iceland to the islets and rocks which surround it the evidence is the same. These islets stand up in the form of splintered pinnacles and needles and form the best possible evidence that ice cannot have smothered and smoothed them as it did the Scottish isles. Thus the same writer says: "Rock-needles, which abound on the coasts, are named Drángir by the natives. Some of these are very noble. The entrance of the Isa-fjord is guarded by one such, standing up from a platform of basalt high above the water; it goes by the name of the 'Sentinel.' A curious spire of rock above the Hörgárdalr is illustrated on plate xi. There are needles in the Skaga-fjord off Drangey, and in the Breithi-fjord" (*id.* p. xxix.). The existence of these pinnacles and sharp angled rocks is inconsistent with the former existence of a great glacial covering.

Lastly, the flora and the fauna of Iceland cannot, it seems to me, be explained by any other theory than that they are the shrunken relics

of what was once richer, and that instead of pointing to the former presence of a glacial climate, they point rather to the climate being now more severe than it has ever been since this fauna and flora occupied the island.

That the climate of Iceland has been getting more severe was long ago suggested by the famous traveller Henderson. *Inter alia* he says: "It is evident, from ancient Icelandic documents, that on the arrival of the Norwegians, and for several centuries afterwards, pretty extensives forests grew in different parts of the island, and furnished the inhabitants with wood both for domestic and nautical purposes. Owing, however, to their improvident treatment of them, and the increased severity of the climate, they have almost entirely disappeared."

Elsewhere we read—"In the Middle ages the S.W. parts of the island were covered with forests, and the old sagas report, without attributing anything extraordinary to the fact, that the house and boat builders went to cut logs in the adjacent forests" (Suarfdvela Saga. A. Geffroy, Revue des Deux Mondes, 1st Nov. 1875). "Ollafsson and Pälsson, who themselves saw a tree 12 metres high, heard speak of a ship built of oak which was launched in the Hval Fjördr north of Reykjavik, and thence went to Norway. These travellers in their travels found numerous iron forges, and it was probably the forgers who destroyed the forests" (Reclus IV. 925).

Mr. Watts in his well-known journey across the Vatna Jökull tells us that in passing through woods of birch and willow on the banks of the Gravalanda, he noticed that the largest wood was dead. The important fact for us to remember is that the trees will no longer live there, and are thus in the same position as the pigs, which abounded in the Middle Ages, but which are now very scarce.

The direct evidence again of the glaciers is strongly in favour of their growth in recent times and against their having shrunk.

Mr. Watts says: "When we inspect the glaciers which fringe the south of the Vatna Jökull, we find that they have decidedly advanced; indeed at one point so much so as to almost destroy communication along that part of the south shore. Upon the north we find that a huge tongue of glacier has flowed down full ten or twelve miles beyond the utmost limit assigned to it by Gunlaugson some forty years ago, while the route traversed by that enterprizing man is completely overrun by the ice, and the traditionary road of the Vatna Jökull's verge is now among the high snows of the Vatna" (Across the Vatna Jökull, p. 190).

True, the glaciers of Iceland may, and no doubt do, ebb and flow, but they gain upon the whole, and never would increase to this extent were not the annual accumulation vastly in excess of the waste, and he goes on to urge that the fact is not peculiar to Iceland but has also been noticed in Greenland and Spitzbergen, and says this seems to point to something more than a local advance compensated for by a retreat in other places. It is too rapid an advance to be accounted for by astronomical causes. He goes on to suggest that the Gulf Stream may be shifting, and says it is rather a curious fact

that less American drift wood has been brought to the northern shores of Iceland during late years, and an increased amount has been cast on its southern shores (*id.* pp. 191–193).

The evidence then is very strong and very concurrent against Iceland having shared in the so-called glacial conditions which marked Scandinavia and Britain.

Let us now turn to Greenland. Greenland is now so overwhelmed with ice that even if it had had a former so-called glacial period we should not be easily able to disentangle and separate its traces from those of the Arctic conditions which now prevail there, so that we cannot adduce evidence there of the same kind as we can elsewhere, namely, old polished and striated rocks, boulders, etc.

It is of course very well known that in Greenland there are undoubtedly considerable traces of polishing, scoring, etc., outside the range and reach of the living glaciers. Thus Nordenskiold refers to the extensive rounded, polished and grooved border of land which almost everywhere separates the inland ice from the extreme coast, and he goes on to argue that this points to the comparatively recent retirement of the ice, and he adds, in addition, that none of the numberless small sea basins in North Greenland, in spite of the suitableness of the locality for moss vegetation, have yet become filled with turf even to the depth of a few feet, showing, to use his own words, that the slip of ice-free land is but a child of yesterday. I admit completely Nordenskiold's facts, but I cannot follow his inference. As everyone knows, the coast of Greenland north of a certain latitude is rapidly rising from the sea, and the rounding and polishing and striating of the marginal land was the result not of the action of greatly increased land ice, but of that most effective scraper and polisher—shore ice, acting as it still does on this coast and also on the coast of Labrador.

Now, apart from the smoothing down of this marginal land, I know of no direct evidence in Greenland of a former increased development of ice, but the reverse.

The presence of pinnacles and pillars of rock standing up with a perfectly free space round them, seem here, as in Iceland, to be quite inconsistent with the former existence of an ice-sheet on a much greater scale than now exists. Kane speaks of three pillars of greenstone which he calls "Three Brothers' Turrets." These are situated near Dallas Bay. At Sunny Gorge again, north of 79°, he speaks of a solitary column or minaret tower as sharply finished as if it had been cast for the Place Vendôme; the length of the shaft is 480 feet, rising on a plinth itself 280 feet high, and he named it "Tennyson's Monument."

These would surely have long ago been ground down and swept away if a great mass of ice corresponding to that which we postulate, when we speak of an ice-age, had formerly prevailed in Greenland. The evidence, such as we have it, of tradition and of archæology goes to show that the climate of Greenland has been growing more and more severe within historic times. Its glaciers have undoubtedly been growing and extending over districts where formerly a much

more temperate climate prevailed, and notably in the days of the Norwegian Settlement. The ice has in many places encroached upon the dwellings and hunting grounds of the Esquimaux, which are no longer habitable, and the skulls of Musk Sheep, etc., have occurred where these animals can no longer find feeding ground.

Of late years, says Nordenskiold, the rowing of an umiak in Tessiursarsoak has been rendered difficult by ice-blocks fallen from the glacier, which is said not to have been the case formerly; and one of our rowers, Henry Sissarniak, even affirms that he rowed without obstruction seven years ago round an island which now forms a peninsula jutting out from the margin of the inland ice. Many similar examples in North Greenland are adduced, thus for example, the glacier that issues into Bläsedal, near Godhavn, has since the time when Dr. Rink mapped that place advanced much further into the valley; in the fjords around Omenak the ice has advanced considerably within the memory of man; a path, formerly often frequented between Sarfarfik and Sakkak, is now closed by inland ice, etc., etc. A similar case occurs in Jakobshavn. In a word, he says, there can be no doubt that in many parts of North Greenland, the inland ice is certainly gaining ground.

There is no doubt on my mind, says Kane, that at a time within historical and even recent limits the climate of this region (*i.e.* Greenland) was milder than it is now. . . . The stone huts of the natives are found scattered along the line of the bay in spots now so fenced in by ice as to preclude all possibility of hunting and of course of habitation by men who rely on it for subsistence. Tradition points to these as once favourite hunting grounds near open water. At Rensselaer Harbour, called by the natives Annatak, or the Thawing place, we met with huts in quite tolerable preservation, with the stone pedestals still standing which used to sustain the carcases of the captured seals and walruses. Sunny Gorge, and a large indentation in Dallas Bay which bears the Esquimaux name of the Inhabited Place, showed us the remains of a village, surrounded by the bones of seals, walruses and whales, all now cased in ice. (Arctic Explorations I. p. 308–9.) Giesecke noted long ago that the advance of the glaciers at Disco and Noursoak can be noted year by year.

If this be the evidence of more recent times we can supplement it by evidence of another kind. The great sea of inland ice in Greenland is dotted with islets of rock, etc., which are known to the Greenlanders as Nunataks. The unweathered and rugged outlines of these projecting rocks show they have never been smothered by ice, but they are remarkable in another way. Quite a considerable number of plants have been collected from these Nunataks by the Scandinavian naturalists, and as they are isolated and often situated at a long distance from each other, I know of no explanation which will account for this phenomenon except the fact that these Nunataks, instead of having been at no remote time parts of a continuous land surface with a more moderate climate, were smothered in ice and snow, as they must have been, according to the theories current about the condition of Greenland, in the so-called Glacial age. It is quite impossible to suppose that these rocks situated

as they are on the ice plateau of Greenland could have got their vegetable and animal life from any occasional waifs and strays.

I may say that the entire fauna and flora of Greenland points the same moral. It cannot have reached it over the sea, and points unmistakably to its being the shrunken and withered relic of a once much richer life and of once much more temperate conditions. The same argument applies to many of the migrating birds which nest in Greenland but come to Britain and further south to winter. We can only explain their presence in Greenland by the theory that its climate was formerly more temperate instead of more rigorous.

What evidence there is therefore from Greenland is distinctly against its having passed through a similiar phase which in Britain and Scandinavia has given rise to the theory of a glacial period.

Let us now turn to Spitzbergen.

Spitzbergen bears in its very name the evidence of the sharply outlined needle-like contour of some of its mountains. In the Journal of William Bernard, the companion of Barentz, who discovered it, we read: "La terre éstoit la plus part rompue, bien hault, et non autre que monts et montaignes agues, parquoy l'apellions Spitzbergen" (Reclus V. p. 257).

Heughlin describes its west coast as a congeries of deep fjords, and the mountains, to use his own words, as "nicht gesonderte Massen mit vielzackigen, spitzigen Gipfeln auftreten" (Petermann's Mittheilungen, 1871, p. 177).

Elsewhere the same writer compares the rugged and fantastic outline of the island with the crenellated outline of a mediæval castle.

This is assuredly quite inconsistent with Spitzbergen having been smothered with ice, as it should have been in the high latitudes where it is placed, if the so-called Glacial age had ever existed there. Let us continue, however.

"Though I had an opportunity," says Nordenskiold, "of examining in several places in Spitzbergen old beds of glaciers surrounded by solid rocks, I have only very seldom met with any rocks polished and furrowed by glaciers; and those were besides situated on the very edge of the sea. Such extensive and highly polished surfaces of rock as are everywhere met with in Scandinavia are not to be found there." (Sketch of the Geol. of Spitzbergen, p. 7, note.)

The presence of polished rocks close to the sea-level in a country which is rising from the waters so rapidly as Spitzbergen, really points there, as in Greenland, not to old glacier action, but to the scoring of recent shore ice, and thus may also be explained the polished surface of the low-lying Dun Islands, and which have probably risen from the sea quite recently.

The débris of Pleistocene marine life, such as it is, points the same lesson, and Nordenskiold distinctly suggests that in the interior of Ice fjord, and at several other places in Spitzbergen, "one meets with indications that the polar tracts were less completely covered with ice during the Glacial era than is usually supposed" (Geol. Mag. 1875, p. 531).

Nordenskiold says: Our investigations of Spitzbergen throw no light on the transition from the Miocene Period to the Glacial

formation of the present time, or on the nature of the animals and plants that lived in the vicinity of the Pole during the Pliocene and the European Glacial periods. We did not there meet with any deposits that might be regarded as a link between the Tertiary strata at Bel Sound and the present age. . . . Torell and Malmgren found on the shores of Hinloopen Sound and Blomstrand, in an especially interesting layer of earth on the shores of Advent Bay, shells of *Mytilus edulis*, which occurs abundantly along the Scandinavian coasts, but no longer inhabits Spitzbergen; at least, the zoologists of the Spitzbergen expeditions were not able to obtain a single living specimen of it in the dredgings undertaken by several boats almost every day during three summers in the Bays and along the coasts of Spitzbergen. Immense numbers of this shell still inhabit the shallows and banks laid bare by the tide at Tromsö and Hammerfest (Sketch of the Geology of Spitzbergen, pp. 52 and 53). This assuredly points to the climate having become more, and not less, severe since these shells were deposited.

Nordenskiold says further, "we may assume from many circumstances that the layers with *Mytilus* at Spitzbergen are a great deal younger than the glacial beds of Scandinavia; *so that these northern tracts would have been comparatively free from ice during this European Glacial Epoch*" (*id.* p. 53).

It seems to me, again, that we cannot account for the fauna and flora of Spitzbergen on any other theory than that we have already applied to Iceland and Greenland, namely, that it marks the shrunken relics of what was once richer.

Again, Nordenskiold points to many circumstances proving that the glaciers in Spitzbergen have, during the last few centuries, not retreated but advanced considerably, as for instance, at Horn Sound. That sound was apparently well known to the Dutch, as an old chart marks two anchorages there. They describe the sound as stretching one of its arms, containing two islands, somewhat northward; but at present this arm is occupied by an immense glacier, and excepting some small rocks there are no islands to be found in the bay. A similar case was noticed by M. Robert at one of the arms of Recherche Bay (Bel Sound), and most likely analogous circumstances very much changed the shape of Stor Fjord, the bottom of which is occupied by an extensive and low glacier stretching in an even slope as far as Mount Chydenius. The large islands which, according to old charts, were situated at the inner extremity of the bay, cannot be the same small islets that are now to be found there; and it seems more probable that Mount Gotland, now encompassed by glaciers, and some other neighbouring mountains, similarly shut up by ice, were at the time the whalers visited them surrounded by water, and identical with those islands which on the old charts are called Sea Horse Island and Seal Island. At Bel Sound I myself witnessed a most striking proof of glaciers, thus descending upon tracts hitherto free from ice. On the north coast of Bel Sound, directly to the east of the large island which separates Van Mijens Bay from the main bay, there existed only a few years ago one of the best harbours in Spitzbergen. The whalers, on their way from the north coast to Stor Fjord, used

often to anchor at this harbour in order to hunt reindeer in the neighbouring fertile valleys; and this, too, was one of the first places visited by Professor Torell's Expedition in 1858. . . . During the winter of 1860–1861, the previously insignificant glacier descended upon the lowland and the grave-hillock on the shore, filled up the harbour and extended far into the sea. It now constitutes one of the largest glaciers of Spitzbergen, from which immense blocks of ice constantly fall down so that not even a boat can venture in safety beneath its broken border (Sketch of the Geology of Spitzbergen, pp. 8 and 9).

In the facts which I have collected in this paper I do not profess to have proved an absolutely conclusive case against the extension of a glacial age (other than the one now in progress) to the Arctic lands, but I do claim to have shown that the available evidence points very strongly in that direction, and it seems to me that those who have argued that because there was a large development of ice in the form of glaciers in more temperate regions there must also have been a corresponding development in much higher latitudes, have not only taken for granted what ought to be proved, but have confused the problem of discovering a true explanation of the so-called Glacial age itself. To this latter problem I hope to be allowed to devote a few sentences on another occasion.

IV.—The Growth of the Indian Peninsula.

By Philip Lake, M.A., F.G S.,
Late of the Geological Survey of India.

IT is one of the most fascinating of the recreations of a geologist to attempt to reconstruct the physical features of some past period; and though our essays in this direction have not been attended with complete success, and our maps of early epochs bear a striking resemblance to those of Herodotus and Ptolemy, yet these maps have their value and they are at least steps towards one of the goals of the science of geology.

But great though the value of a good map of some past period may be, its interest lies not so much in itself as in its relations to those of earlier and later periods. We wish to see how the geography of one period grew out of that of the preceding.

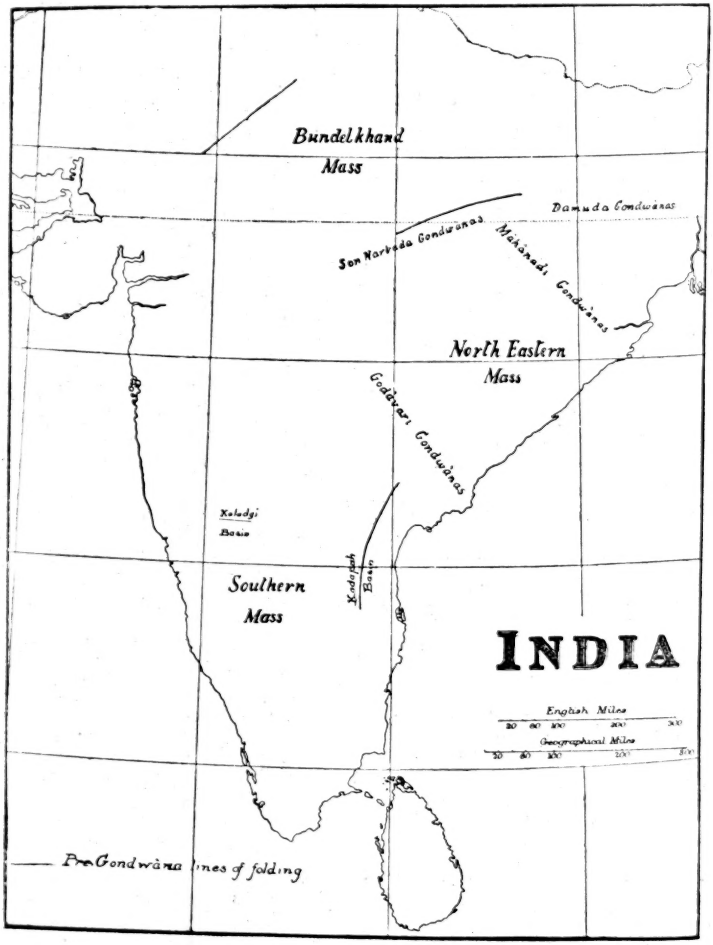
In some areas the geographical changes have been so numerous and so various that this is practically impossible; but in others the changes have been simpler, and we are able to trace with more or less certainty the evolution of the present geographical features.

The Peninsula of India is a case in point. Its growth—not from one, but from three centres—appears to have been nearly continuous; and the present peninsula has been formed by the final union of these three masses. Only along the western coast does there appear to have been any serious interference with the general plan of growth; for the complete absence of anything but gneiss, trap, and very late Tertiary beds on this coast, except in the north, seems to suggest that the coast itself is of very recent formation.

For our present purposes the rocks of the Peninsula, under which term is included the whole of India south of the Indo-Gangetic plain, may be divided into three great divisions, viz.:—

Post-Gondwàna.
Gondwàna.
Pre-Gondwàna.

The Pre-Gondwàna division includes the Gneissic, Dharwar, "Transition," and Vindhyan series, and as fossils are absolutely unknown, we are unable to correlate these series with European rocks. The Gondwàna formation probably ranges from Upper Carboniferous to Tithonian or Portlandian; and the Post-Gondwàna, which includes the marine beds of the coasts, the Deccan Trap, and the Tertiary and later beds, ranges from Upper Jurassic to the present day.



On the map accompanying the Manual of the Geology of India, there may be seen in the Peninsula three main areas of Gneissic rocks:—(1) the Southern Mass, bounded on the north by the Deccan Trap and the rocks of the Godàvari basin; (2) the Bundelkhand Mass, a semicircular mass immediately south of the Gangetic Plain; (3) the North-Eastern Mass, occupying a large area in Bengal and the Central Provinces, and separated from the Southern Mass by the Godàvari area of later beds. The positions of these masses are shown on the accompanying map.

Up to the beginning of the Gondwàna period each of the three masses had its own history, distinct from that of the others, and each must therefore be treated separately.

Pre-Gondwàna History.

Growth of the Southern Mass.—The greater part of India south of the Kistnah is composed of gneissic and granitoid rocks, but it is traversed by a number of nearly parallel bands of schist, together with conglomerates, haematite beds and lava flows, to which has been given the name of Dharwar Series.[1] Many of the schists seem to be altered lavas, and the whole series must have been largely volcanic. The direction of the bands is N.NW.–S.SE.; and it is clear that the Dharwars originally covered the whole, or nearly the whole, of the gneiss, and that they were afterwards thrown into folds running N.NW.–S.SE. (nearly parallel to the present west coast). Afterwards the whole mass was subjected to denudation, so that only remnants of the Dharwars were left, running as bands through the gneiss (see Woodcut-Section, Fig. 1).

Fig. 1.—Diagramatic Section of the Southern Mass.
a, Gneiss. *b*, Dharwar series. *c*, Kadapah series. *d*, Karnul series.

The folding and denudation of these rocks were completed before the deposition of the next set of beds, which were laid down as a fringe on the N., N.E. and E. sides of the gneiss mass, forming now the Kaladgi, Godàvari, and Kadapah basins. These basins were probably originally continuous with one another and their present separation is due to denudation.

The Kadapah basin is crescentic in shape and lies on the east side of the gneiss mass. The older ("Kadapah") rocks of this basin in the western part of the area, rest quite flatly on the gneiss

[1] See especially Foote, Rec. Geol. Surv. India, vol. xxi. p. 40; vol. xxii. p. 17. Mr. Foote gives a map of these bands.

or slope gently away towards the east. The higher beds overlap the the lower towards the west; and this, together with the fact that conglomeratic beds are not uncommon, leads one to conclude that the present western boundary of the basin is not far from the old coast-line.

Further east, as the distance from the old coast-line increases, these rocks become more and more folded; and on the eastern side of the basin are frequently reversed. The direction of the folds is nearly N.–S. (Fig. 1).

In the Godâvari basin, which lies to the north of the Kadapah basin, similar beds are found, and here also in the west they are but little disturbed, while further east they are affected by the disturbances which folded the corresponding part of the Kadapah basin.

Hence we may conclude that a series of deposits (the "Kadapah" beds) was laid down on the eastern coast of the gneiss mass; and that ultimately these were crushed up against the gneiss. Near the old coast-line they remained almost undisturbed, whilst further out towards the east they were thrown into a series of N.–S. folds (see accompanying section).

Nearly the same course of events appears to have taken place on the north coast of the old gneiss mass, where we now have the Kaladgi basin of rocks similar to those of the Kadapah basin. The lowest beds, found at the south border of the basin, are conglomeratic, and evidently shore deposits, so that the coast of that time cannot have lain far south of the present boundary of the basin.[1] The beds of the Kaladgi basin have been thrown into folds running W. by N.—E. by S.; and the disturbance is greatest on the N. side of the basin, *i.e.* at the part furthest from the old shore—though this is not so well marked as in the Kadapah basin.

In the Kadapah basin the older (Kadapah) rocks which are affected by the folds already described, are overlaid by later rocks called the Karnuls, which serve to fill up the space between the great folds on the east and the old shore on the west (see section). They are but little disturbed and overlap on to the gneiss.

On the north of the gneiss similar beds are found in the Bhima basin near the Kaladgi basin. Here also they are little disturbed; but their relation to the rocks of the Kaladgi basin is nowhere shown.

After the deposition of these later beds (which are still pre-Gondwâna) the Southern Mass has never received any further deposits, except close to the coasts, and it has remained land since that time.

Growth of the Bundelkhand Mass.—The Bundelkhand gneiss now forms a semicircular patch, bordered on the N.E. by alluvium, and elsewhere chiefly by the well-known Vindhyan rocks.

On the S.SE. border, which runs from E.NE.—W.SW., there is a fringe of quartzites, limestones, etc., known as the Bijâwars. These lie nearly horizontally on the gneiss and towards the south are covered by an extensive spread of Vindhyan beds; but before they disappear they begin to be crushed and folded. They were

[1] *Cf.* Foote, Rec. Geol. Surv. India, vol. xv., p. 191, and King, Mem. Geol. Surv. India, vol. viii., pl. ix., section i.

apparently shallow water deposits and never extended much further north than at present.

To the south of the Vindhyan spread they reappear in the Son-Narbada and Son areas; where they form a band running parallel to the Bundelkhand Bijàwar band. In the Son area especially they are strongly folded.

Here then again we have a series laid down upon the gneiss and subsequently folded. Close to the gneiss the beds are almost unaffected, while further away they are greatly disturbed.

To the north of the Bundelkhand gneiss we find very much the same thing. Close to the gneiss, at Gwalior, we have almost undisturbed Pre-Vindhyan beds; while further away, in the Arvali Hills, the Pre-Vindhyan beds are strongly folded, the folds running about N.E.–S.W.

Towards the S.W. the Bundelkhand gneiss disappears beneath Vindhyan beds and the Deccan Trap; but at intervals we find inliers of Bijàwars and similar rocks resting on gneiss, in the Dhar Forest, and at Narsingpur, Champanir, Bagh and Jobat.

If the beds at Bijàwar and Gwalior are really shore deposits, close to the old coast-line, it is clear that the Bundelkhand Mass had a history very similar to that of the Southern Mass. Beds were laid down on its borders and afterwards crushed up against it, the most intense folding being at a considerable distance from the old shore.

In the space between these folds (the folds to the S.E. and the folds to the N.W. [see map] of this gneiss) we now find a large spread of Vindhyan rocks. These are little disturbed and may at one time have covered the whole of the gneiss mass.

Growth of the North-eastern Mass.—In the present state of our knowledge, it is impossible to trace the history of the N.E. Mass, even with the same degree of uncertainty as we have traced that of the others. Large areas are covered by Lower Vindhyan and older rocks, but these have not been examined in detail.

No rocks of later age than Lower Vindhyan are known between the Máhánadi and Godàvari Gondwàna basins; and the area has probably been land since Lower Vindhyan times.

Gondwàna History.

The Pre-Gondwàna history of the Southern and Bundelkhand Masses appears thus to have been nearly the same. Beds were deposited on their borders and afterwards crushed up against the unyielding gneiss. At a considerable distance from the shore this crushing caused intense folding, and no doubt elevation; and the space between the folds and the shore was subsequently filled by later rocks, which overlapped on to the gneiss and, in the case of the Bundelkhand Mass, perhaps covered the whole of the gneiss.

Somewhat in this fashion the three great masses appear to have grown outwards until, at the beginning of the Gondwàna period, only comparatively narrow spaces were left between them; and in these spaces the Gondwàna rocks were deposited. They now form strips between the Southern and North-eastern Masses (Godàvari basin); between the Bundelkhand and North-eastern Masses (Son

and Narbada areas); and on the north of the North-eastern Mass (Màhànadi, and perhaps Damuda, Gondwànas).

The complete absence of any trace of Gondwàna or later deposits on the Southern Mass (except near the coasts) and on the rocks of the Bundelkhand area, shows that these areas have been land since Vindhyan times. How much of the North-east Mass was land in Gondwàna times it is difficult to say. In the Godàvari basin, the Lower Gondwànas appear along the S.W. border of the field, while higher beds abut against the N.E. border. This may be due to a fault, or to overlap of the higher beds on the N.E. side. In the former case the Gondwàna rocks extended over the North-east massif beyond their present limits; in the latter case the N.E. border of the basin must be near the original shore.

However this may be, some part of the North-east Mass was probably land in Gondwàna times; and the Gondwàna rocks were deposited in arms of water between this land and the Bundelkhand Mass on the N.W. and the Southern Mass on the S.E. They were also laid down on the northern border of the North-east massif (Màhànadi area, etc.).

The Gondwàna beds appear to be chiefly fluviatile and to have been deposited under much the same conditions as the alluvial deposits of the Indo-Gangetic plain. These Indo-Gangetic deposits, it will be noticed, also fill up the space between two pre-existing land areas.

In this way the deposition of the Gondwànas completed the union of the three elements of the Indian Peninsula. Throughout the whole Peninsula no marine beds of later than Gondwàna age are found except near the coast, and the whole area has been land since that time.

Post-Gondwàna History.

But little now remains to be said. The outflow of the Deccan Trap must have greatly changed the configuration of the surface, and may perhaps have altered the northern part of the west coast; but beyond this it does not appear to have affected the general disposition of land and sea.

The presence of marine Jurassic and Cretaceous beds on the coasts, shows that the whole Peninsula has risen since Gondwàna times.

But the most important alteration is one of which we have only negative, and therefore doubtful, evidence. It will be noticed that up to very recent times no deposits of any kind were laid down on the west side of the Southern Mass, while rocks from the Kadapah period downwards were deposited on its northern and eastern shores. It is, therefore, not unlikely that the present west coast of the Southern Mass was not a coast till late Tertiary times; *i.e.* that the Southern Mass extended far to the S.W. of its present limits—and in this connection it is interesting to note that this would give us the "Lemuria" of Wallace, or Gondwàna land of Suess and Neumayr. In Tertiary times the western part of this land disappeared, and the remaining fragment now forms the southern part of the Indian Peninsula.

V.—The Relative Age of Flints.

By A. J. Jukes Browne, F.G.S.

MR. G. ABBOTT is quite right in saying (Geol. Mag. for June, p. 275) that much work has yet to be done before we understand the formation of flints, and I would add that the work required must include observations on other siliceous concretions such as chert and cherty nodules of all kinds. It is also unquestionably important that we should, if possible, ascertain whether such concretions were formed contemporaneously with the deposits in which they are now found, or whether they are a sort of separation product formed during the consolidation of the rock after upheaval above the sea.

To Mr. Abbott, as to many observers, the vertical veins of flint so often present in Upper Chalk, and termed by him "tabular flint," prove a stumbling-block. These veins do certainly appear to have been formed during or after the consolidation of the Chalk; but need we on this account proceed to assume that all other flints and cherts are of subsequent growth? Surely it is at least possible that some forms of flint are of contemporaneous origin, while others may be of subsequent date.

Before discussing this difficult question let us clear the ground a little by making a rough classification of flints. Mr. Abbott makes no mention of the horizontal or interbedded floors of flint which are sometimes continuous over many square miles (*e.g.* in Kent and Lincolnshire). These are much more correctly called "tabular flints" than the vein-courses which cut the beds at various oblique angles. No one who examines them could doubt that they are interstratified beds and not infilled cracks, though of course it is open to question whether they were always layers of flint.

Chalk flints may I think be classed under four heads:—

1. Nodular flints.
2. Tabular flints and flint floors.
3. Vein-courses.
4. Paramoudras.

An acquaintance with flints and their different modes of occurrence extending now over more than twenty years has only served to strengthen my belief that flint nodules and tabular flint-floors have been formed while the Chalk was being accumulated. I would not deny that the making of a flint may have been a long and slow process; there may have been a succession of phases and changes before an incipient nodule became a hard and glassy flint, but I think that the whole process must have been accomplished while the superincumbent chalk was still soft chalky ooze, and while it was still saturated with sea-water.

It is, perhaps, not generally known that the flints of the successive zones of the Upper Chalk have special characters of their own. The characters of the flints in a given zone are not exactly the same throughout England, but within certain areas they appear to be constant, and they have been used by Dr. Ch. Barrois and the late

Prof. Hébert as aids in dividing one zone from another. Further observations on this succession of forms of flint, with the view of determining how much dependence can be placed upon them, would be very useful; but the fact of there being differences is unquestionable and is evidence for the contemporaneous origin of the nodules.

The flints with hollow tubular cores and spaces to which Mr. Abbott refers are specially characteristic of the *Micraster corangui-num* zone, and have generally been formed round the bifurcating branches of *Doryderma ramosum* (*Spongia ramosa*, Mantell), not round *Siphonia* stems as he imagines. *Doryderma* was a siliceous (Lithistid) sponge and its subsequent solution has left the flints in the condition which Barrois calls *cariés*.

Now it is clear that in such nodules the flint must have been formed around and attached to the body of the siliceous sponge before its solution, and must have been as hard as it is now when the sponge tissue was dissolved out. The solution is not likely to have been accomplished until after the upheaval of the Chalk, *ergo*, the flint was there before. It is quite true that sometimes the cavities are partially or even wholly filled with subsequently-deposited siliceous matter, but this is usually chalcedony and is quite different from the external flint.

Mr. Abbott's suggestion to account for the supposed absence of flints in the Lower Chalk cannot possibly be accepted. He does not seem to know that what was formerly called "Lower Chalk" is now divided into *Middle* and *Lower* Chalk. Flints are common in the upper part of the Middle Chalk and though they do not occur in the Lower Chalk of the South-east or of the Midlands, they do occur in it and very low down in Devon, Dorset, and Yorkshire.

Mr. Abbott is quite right, however, in saying that flints can be found in every stage of development, and a study of these incomplete flints with the aid of a microscope ought to give us some insight into the manner of their construction. My friend Mr. W. Hill, F.G.S., has for some years been occupied in the study of such flints, and I understand that he intends to publish some of his observations at an early date. He agrees with me in regarding the imperfect flints as cases of arrested development apparently for want of a sufficient supply of silica.

The co-existence of flint and chert with a prevalence of sponge spicules is too frequent to be a mere coincidence. All who have recently studied siliceous nodules, notably Dr. Hinde, Prof. Sollas, and Mr. W. Hill, have connected the formation of the concretions with the occurrence of the siliceous sponges. But as to the details of the processes whereby the silica of the sponges has become concentrated in the siliceous nodules and layers we are at present very much in the dark. More observation and experiment is required before Nature yields up this long-treasured secret; but I can see no good reason why the initial formation of all the siliceous nodules, which occur in limestones, should not have been due to the same causes which have led to the production of calcareous and phosphatic nodules in sands and clays; and in the formation of these it is clear

that the decomposition of organic matter has played a prominent part.

Lastly, with regard to the vein-courses, I can confirm Mr. Abbott's observation as to the frequency of two layers, and I agree with his conclusion that they must have been formed in fissures, for I presume he means any kind of fissures, such as open joint-planes, and not necessarily faults. This being so, one would certainly have expected that the microscope would disclose some points of structural difference between the flint of veins and that of nodules. Mr. Hill however assures me that he cannot detect any material difference, and it would seem therefore as if we must admit that true flint can be formed in spaces which have been open cracks. It is quite possible however that the deposition of the silica in these cracks took place as soon as the cracks were opened, that is to say during the first upheaval of the mass and while the occluded sea-water was passing away from it. This water must have contained much silica in solution and the mere relief of pressure by upheaval may have been sufficient to cause precipitation of the dissolved silica, though why true flint and not chalcedony was deposited I am quite unable to explain. Similiar veins sometimes occur in the chert-beds of the Upper Greensand, but the silica in them is always chalcedony.

If the flint-veins were formed after complete upheaval and by deposition from water percolating down from the surface of the land, it is difficult to understand when and under what conditions such water could first of all take up silica and then deposit it as flint. Such water would be much more likely to leave veins of calcite behind it, and calcite crystals do not unfrequently occur in empty shells of *Ananchytes* and *Terebratula* and in the cracks which often occur in the beds of "Chalk Rock."

At the same time I admit that there are veins of flint which seem to have originated after the later disturbances of the Chalk, but the theory above suggested would still apply to such cases if we can assume that the areas in which they occur had not previously been raised above the sea level.

There are also chemical questions which probably a little experiment would answer: imagine a mass of chalk for the first time upheaved above the sea-level, the sea-water with which it was saturated and which probably retained much silica in solution would sink to the parts below sea-level, and rain-water, taking up carbonate of lime, would percolate downward. Now what would happen when the carbonated water came in contact with that containing silica, would not the silica be precipitated?

In this paper I have only dealt with the general aspect of the question; the manner in which flint was formed is undoubtedly a great puzzle, and it will not be solved without much patient investigation. So far as I am aware flints only occur in very pure *chalky*-limestones, such as Cretaceous Chalk and the Portland Limestone; but their occurrence in the latter shows that very deep water was not necessary for their formation.

VI.—New Classifications of the Brachiopoda.

By Agnes Crane.

MR. CHARLES SCHUCHERT, of Newhaven, Conn., U.S.A., has recently published in the "American Geologist" (Vol. xi. No. 3) an important and highly suggestive "Classification of the Brachiopoda," based on the history of the class (Chronogenesis) and the ontogeny of the individual. It embodies the latest results of the remarkable investigations on the Palaeozoic forms of Prof. James Hall and Mr. J. M. Clarke, who have thrown so much light on the evolution of genera among the Brachiopoda in the eighth volume of "The Palæontology of New York" (Part I. Brachiopoda, 1892).

Mr. Schuchert adopts the ordinal system proposed in 1891 by Dr. C. E. Beecher and thus divides the Cuvierian class Brachiopoda into the free and attached valves or *sub-classes Lyopomata* and *Arthropomata* of Owen, and the following sub-orders of Beecher, based on the nature of the pedicle passage and the stages of shell growth. (1) *Atremata*, with a free pedicle; (2) *Neotremata*, with pedicle opening in the ventral valve; and (3) and (4) *Protremata* and *Telotremata*, their modified respective derivatives. Three out of these four sub-orders were represented in the primordial fauna, and genera belonging to the fourth "were in existence in the Trenton period of the Lower Silurian."

In 1877 one hundred and thirty[1] genera of Brachiopoda were recognised and divided by Dall into eighteen, and by Davidson, first into eleven,[2] and subsequently into fourteen family groups. Messrs. Hall and Clarke seemed inclined to abandon family designations altogether and left the consideration of the matter for the second part of their work on the Palæozoic genera (*loc. cit.*). Meanwhile Mr. Schuchert has carefully performed a useful work in tabulating the enormous increase of genera recorded during the last sixteen years. They amount in all to rather more than twice the number, viz., two hundred and seventy-seven genera, which he classifies into forty-seven families, and proceeds to show that thirty-six out of these forty-seven were differentiated during the Palæozoic, that only nine survived in the Mesozoic, while six, or one-eighth of the whole number, are represented in the living faunas of existing oceans.

Twenty-four genera are referred by Schuchert to the order Atremata, the oldest and simplest in structure, from which the Neotremata and Protremata almost simultaneously diverged. In the Telotremata, the most modern and numerous sub-order, he includes no less than one hundred and thirty-eight genera—the half of the whole—and considers these rostrated forms as all directly derived from the Neotremata. *Paterina* is regarded as the most primitive known genus of the order Atremata, which gave rise through the *Trematidae* to the *Neotremata*, while the *Protremata*

[1] "What is a Brachiopod?" Geol. Mag. June, 1877, Decade II. Vol. IV.

[2] General Summary of the "British Fossil Brachiopoda," Palæontographical Society, 1884.

originated from the Atremata by way of the *Kutorginidae*, "one of the first steps from the inarticulata towards the articulate forms of which *Orthis* can no longer be considered as the prototype, as Hall has recently shown that no true *Orthis* exists in the primordial fauna."

Within the compass of eight and twenty pages Mr. Schuchert has produced a valuable epitome of the life-history of this extensive group of ancient and persistent organisms, a difficult and laborious task. He gives a plate (V.) showing the apparent genesis of the forty-seven families and their geological distribution and a tabular view of the geological range of the two hundred and seventy-seven genera entitled to rank as such in his opinion. Concise explanatory notes add to the value and comprehensibility of the associated textual classification. This combines some of the leading ideas of Von Buch, Eugène Deslongchamps, James Hall, Beecher, Gray, Dall, Waagen and Neumayr with original additions as regards sub-orders, new family and sub-family groups.

Thus, he divides the order PROTREMATA into two new sub-orders: 1. TRULLACEA, derived from *trulla* a scoop, defines the spoon-shaped plate, or spondylium of Hall, which covers the delthyrium in the families *Kutorginidæ, Clitambonitidæ, Pentameridæ* and *Porambonitidæ*. 2. THECACEA, from *theca* a cover, for those forms in which the spondylium is absent and the apical three-cornered fissure or delthyrium is covered in the ventral valve by a single plate—the true deltidium. This includes the families *Billingsellidæ, Strophomenidæ, Thecididæ, Productidæ*, and *Orthidæ*, with allied sub-family groups also as emended. 3. ROSTRACEA, a sub-order of TELOTREMATA is restricted to forms devoid of spondylium "or any calcareous brachial supports, other than freely terminating crura." It therefore includes the families *Rhynchonellidæ* (Gray) and *Eichwaldiidæ*, n.f. (Schuchert).

The following nine new families in all are added: *Paterinidæ, Lingulellidæ, Lingulasmatidæ, Trematidæ, Acrotretidæ, Kutorginidæ, Clitambonitidæ, Billingsellidæ*, and *Eichwaldiidæ*. Some new sub-families are also proposed, and others well-known, raised to the rank of family groups, increase the total to forty-seven in number!

In applying the law of morphogenesis, first defined by Professor Hyatt, to the Brachiopoda, Dr. Beecher adopted much of Hyatt's nomenclature. Mr. Schuchert follows suit, although the etymological deficiencies of many of the terms such as *nepionic, ephebolic, clinatologic*, etc., have been freely criticised by Messrs. S. S. Buckman and F. A. Bather in a recent communication to the Zoologischen Anzeiger (No. 405 and 406, Nov. 1892). As the application of the laws of growth, or the science of Auxology, as Buckman and Bather have happily termed it, is rapidly coming into general use and is likely to develop, it seems a matter of regret that American and European biologists cannot define a set of terms for common use not susceptible of modification and variation by etymological purists of the future. Either the invalidity of recent criticisms should be demonstrated, or the modifications proposed adopted as tending to promote uniformity of nomenclature,

and that simplification of knowledge which should be the aim of every true lover of science when combined with strict accuracy of statement and observation. American scientists have produced of late so much sound and original work relating to the individual development and genetic evolution of the Brachiopoda that it is a pity that merely finishing touches in this department should be left to Europeans.

A revision of the families of the loop-bearing Brachiopoda was issued contemporaneously by Dr. Charles E. Beecher[1] to whom Mr. Schuchert expressed his acknowledgments for advice and assistance during the consideration of his new Classification of the Brachiopoda in general, wherein all the Terebratuloids are divided into the three families of the *Terebratulidæ*, *Dyscoliidæ*, and the *Terebratellidæ* grouped in nine sub-families.

Dr. Beecher's revision is simpler in character, as he recognizes only two families and seven sub-families. In the first division, for which he retains Gray's family name of *Terebratulidæ*, he places the *Centronellinæ*, Waagen; *Stringocephalinæ*, Dall; *Terebratulinæ*, Dall; and the *Discolinæ*=the family (*Dyscoliidæ*) of Fischer and Œhlert. This last comprises the recent genera of *Dyscolia*, of which *Terebratulina Wyvillei*, Dav., is the type. *Eucalathis*, type *Terebratula trigona*, Jeffreys, and King's sub-genus *Agulhasia*, of which a single species (*A. Davidsoni*) was dredged off the Cape of Good Hope, thus ranging from the Cretaceous to the recent period. The two former occur living in the Lusitanian and West African "Provinces," and are represented by fossil species in the Pliocene deposits of Sicily. Dr. Beecher considers all the Dyscoloids as degraded forms not representative of the highest development of the family type, and that the adult arm-structure in *Dyscolia* is homologous with early larval features of *Terebratulina*, as described by Morse.

King's family of *Terebratellidæ* is re-established and emended by Beecher, who divides it, however, into three sub-families. The prominent feature in this revision is the confirmation and adoption of the main results of the developmental studies of various species of recent *Waldheimiæ* by Friele, Fischer, and the Œhlerts. The Norwegian conchologist was the first to study the successive metamorphoses of the loop in the Northern forms, long known as *Macandrevia cranium* and *Terebratula* (*W.*) *septigera* of Löven. The French zoologists quite recently announced that the results of their investigations of the development of the Southern forms of the same group now called *Magellania*, *M. venosa*, *M. lenticularis*, etc., indicated divergent lines of development such as would necessitate the division of the recent species into two sections, each characterized by serial differences of gradational metamorphosis and adult features, as well as by important geographical limitations.[2]

[1] "Revision of the families of Loop-bearing Brachiopoda;" "The Development of *Terebratalia obsoleta* (Dall)," with three plates, by Charles E. Beecher. Transactions of the Connecticut Academy of Sciences, vol. ix. March, 1893.

[2] Sur l'evolution de l'Appareil brachial de quelques Brachiopodes, *Comptes Rendus*, November, 1892.

These discoveries Dr. Beecher now confirms and emphasizes by dividing *Terebratellidæ* into three well defined families: 1. *Dallininæ*, 2. *Magellaniinæ*, and 3. *Megathyrinæ* (= *Argiopinæ*), comprising adult genera which indicate the larval conditions of both the higher groups, each of which ultimately terminates in a form superior to that of the adult *Terebratallia*.

The first *boreal* sub-family receives its designation from the new genus *Dallina*, in which Dr. Beecher has placed the old familiar form of *Terebratula* (*W. septigera*, Löven), paying a just tribute to the excellent work of Dr. W. H. Dall, the *doyen* of the recent Brachiopodists of America. It would, perhaps, have been more graceful to have renamed this northern species after the Norwegian conchologist who first made known the successive stages of the loop development in the boreal type, and to have associated Dr. Dall's name with the new genus *Terebratalia* founded by Beecher, with *Terebratella transversa*, G. B. Sowerby, as type, for it is with the metamorphoses of the *Terebratellæ* that the American brachiopodists' work is more intimately connected. The genera *Macandrevia*, King; *Dallina*, Beecher; *Eudesia*, King; *Terebratalia*, Beecher; *Trigonesemus*, Koenig; *Lyra*, Cumberland; *Laqueus*, Dall; *Muhlfeldtia*, Bayle; *Kingena*, Dav.; *Ismenia*, King; and *Platidia*, Costa; are placed in the sub-family *Dallininæ* of Beecher.

The second sub-family receives the name of *Magellaniinæ* from the culminating type *Magellania* (*Wald.*)*venosa*, Sol.; and the genera *Terebratella*, D'Orb.; *Magasella*, Dall; *Magas*, Sowerby; *Megerlina*, Deslongchamps; *Bouchardia* and *Kraussina*, Davidson, are included therein.

The third sub-family *Megathyrinæ*, Dall, comprises only the recent *Megathyris* (=*Argiope*) *Cistella*, Gray; *Gwynia*, King; and the Liassic *Zellania*, Moore.

The lower genera in all the sub-families do not complete the series of development, but the higher forms pass through all the successive grades. It would seem therefore that both branches of the *Terebratellidæ* originally sprang from some minute form allied to the insignificant atavistic *Gwynia* of existing oceans and Tertiary deposits. Palæontologists should therefore turn their attention to this small but interesting survival of the ancestral terebratelloid type, which doubtless lived before the Jurassic period, when several well-marked genera were in existence. Exact knowledge of the stage of loop development attained by many of the so-called *Waldheimiæ*, of the old terminology, is still lacking. This department of science lost in Eugène Deslongchamps an enthusiastic and capable investigator, a philosophical student of the living forms, and well acquainted with the genetic distribution and succession of the Jurassic species. His work is evidently known and appreciated in America.

Dr. Beecher considers that the radical stock of the Terebratelloids early branched off in two directions. Changing environments accelerated development and thus genera were prematurely launched on the sea of life, and in their turn perpetuated arrested types of inferior grades of structure, while others again passed up into higher

phases before attaining maturity. The result was almost the same in the end, as each branch produced forms with a long free loop characteristic of *Dallina septigera* in the northern oceans and somewhat modified in *Magellania venosa* of the southern oceans.

The Megathyrinae appear to represent the stem from which both branches of the Terebratelloids diverged, and we should not be surprised if the *Centronellinæ* were ultimately found to occupy the same position at the base of the *Terebratulidæ* (*emend.* Beecher). It is to this Palæozoic sub-family that the interesting new genus *Hallina*, which seems to be a mixed type, is referred. It is described as a small articulate shell, rostrate, biconvex, semiplicate with incomplete deltidial plates "and calcified brachial supports comparatively long and in form much as in *Waldheimia*." This is the oldest Terebratuloid known, and is represented by two widely distributed species in the Trenton and Hudson River groups of the Lower Silurian of New York, Iowa, Minnesota, Tennessee, and Kentucky.[1]

Dr. Beecher gives three plates illustrating the individual and genealogical development of the *Terebratellidæ* figuring the gwyniform, cistelliform, bouchardiform, megerliniform, magadiform, magaselliform, terebratelliform, and ultimate magellaniform phase successively assumed by the higher members of the sub-family *Magellaniinæ* of the southern oceans. The gwyniform, cistelliform, platidiform, ismeniform, muhlfeldtiform, terebratelliform, dalliniform grades of the boreal sub-family *Dallininæ* are placed side by side for comparison.

An interesting account is added of the "development of a new form *Terebratalia obsoleta*," Dall, a Californian brachiopod, originally described by Dall as a variety of his *Terebratella occidentalis*; but now, not only admitted to rank as a distinct species, but, according to Beecher, representing an adult stage in the development of *Terebratella* differing so much from the typical *Terebratella dorsata*, Gmelin, that it is given generic rank as *Terebratalia*, Beecher. To this new genus the species, hitherto known as *Terebratella transversa*, *frontalis*, and *coreanica*, are also referred, with *T. transversa*, G. B. Sowerby, as the type.

We were not aware, prior to reading the footnote on p. 383 of Dr. Beecher's paper, that *Megerlina* was a synonym of *Megerlia* (now called *Muhlfeldtia*); but considered that Deslongchamps' name represented a valid sub-genus of *Kraussina*. Indeed, this seems to be the view Dr. Beecher has also taken in the text on p. 380!

Some confusion is excusable. A pocket guide to the synonymy of the Brachiopoda would be useful at this juncture; but, like some of the missionary vocabularies of native South American dialects, it might become obsolete before the generic and specific compilation was completed, for the Brachiopodal nomenclature has been shifted of late with kaleidoscopic rapidity. However, as has been well said by an American writer: "The foolish and the dead alone never change their opinions."[2]

[1] "New Brachiopoda from the Trenton and Hudson River groups of Minnesota." By N. H. Winchell and Charles Schuchert (American Geologist), vol. ix. May, 1892.

[2] Lowell.

There can be no doubt that a morphogenetic classification and nomenclature embodying the results of general researches into specific development is a material advance, and that all generic and sub-generic names which define and record either well-characterized phases in actual development, permanently stereotyped as fossil genera, must be recognized as valid. Thus we may hope at last to arrive at the true filiation of the fossil forms and their living descendants.

It is to the investigations of Friele, Eugène Deslongchamps, Dall, Morse, Brooks, Beyer, Beecher, Shipley, Schulgin, Kowalevesky, Lacaze-Duthier, and last but not least to those of Fischer and Daniel and Pauline Œhlert that we owe the great advance of our knowledge of the genealogy of the recent Brachiopoda. We seem to have arrived at a turning-point in the history of the race.

VII.—The Cause of Crateriform Sand Dunes and Cwms.

By William Shone, F.G.S.

At St. Anne's-on-the-Sea, Lancashire, there are a great number of very large sand-hills. They are for the most part crateriform in the centre, from the gyratory movement of the wind in stormy weather. There must be some cause, however, which determines the course of the wind, for its natural action one would suppose should be to carry away dunes by sweeping them before it.

I believe the *initial* cause of crateriform sand dunes is rain. The dunes are so porous that the rain does not run off the outsides but sinks through them, carrying particles of sand with it as it sinks to lower levels. This is especially the case when the base of the sand-hill rests upon quicksand. The internal abstraction of sand is greatest in the centre and least at the sides—hence the formation of a *central initial* cup.

During the wet season in Sept. and Oct., 1892, I had many opportunities of studying such phenomena at St. Anne's-on-the-Sea. In one instance I was fortunate enough to observe one of these rain-made hollows formed. It occupied the centre of a deep crateriformed sand dune. It was forty-eight inches in diameter and twenty inches deep in the middle. The centre of the hollow had reached the quicksand which underlies the base of the sand-hill.

Cwms.

May not the similar action of rain, during a lengthened period of time, account for the origin of Cwms. For instance, the beautiful Cwm which forms the N.W. front of Cader Idris, in the hollow of which lies Llyn-y-Gader. Through the moraine matter which stretches across the Cwm, I have heard beneath the surface the noise of the surplus water of Llyn-y-Gader rushing away. Rain is, I think, the Cwm maker as well as the crateriformed dune maker, and both are the effects of sub-ærial denudation and subterranean erosion acting in unison.

I.—A History of Crustacea—Recent Malacostraca. By the Rev. Thomas R. R. Stebbing, M.A. 8vo. pp. i.–xviii. and 1–446, 19 Plates and 32 Figures in the text. One of the Volumes of the International Scientific Series. (London: Kegan Paul, Trench, Trübner & Co., Limited, Paternoster House, Charing Cross Road, 1893.) Price 5*s*.

THE want of a handy text-book on the Crustacea has long been felt, and the neglect into which this great class had fallen, until the "Challenger" volumes made their appearance, is all the more readily to be understood. Grand, however, as the "Challenger" volumes undoubtedly are, they are far too ponderous to put into one's travelling bag, when going down to the sea-side for a fortnight. Moreover, their price, like that of rubies, is above the heads of most work-a-day people, who are well enough educated in Natural History to enjoy and appreciate a quiet sea-side resort, where, pottering around the shallows and rock-pools along the shore, more joy is to be found, than in promenading in new clothes upon the pier, to listen to the sweetest of bands, and watch the prettiest of the fair sex.

Let us then eschew the gay and giddy throng, and taking the Rev. T. R. R. Stebbing for our guide, literally pocketing him, for he only measures $7\frac{1}{4}$ inches by $5\frac{1}{4}$ inches (*the book* of course, not his reverence); let us away to some good spot on the south, west, or east coast, and go a "crabbing" or a "shrimping" and see what comes of it.

"It is not generally known that the species of Crustacea extend to a number of several thousands, and that many of these species people parts of the ocean in enormous swarms. Of some of the groups the general character is familiar to everyone; but there are others of which most persons either know nothing, or have not the least idea that they belong to the Crustacea. The beginner therefore will have provinces of a new world opened to his exploration. There is curiosity to be gratified. The sporting instinct will discover many an unexhausted territory. In the manners and customs of the creatures there is much to afford entertainment, and almost every new observer finds something singular to relate. . . . . Nor need man despair of finding out something for his private and personal benefit while investigating the physiology of a shrimp."

Owing to the limited space at his command, the author has only been able to give us a brief account of the members of one great division of the Crustacea, namely, the *Malacostraca* or *Thoracipoda* (H. Woodw.), the highest sub-class of the whole group; including the Brachyura, the Macrura, the Schizopoda, the Stomapoda, the Cumacea, the Isopoda, and the Amphipoda.

Alas and alackaday! even in this volume, the author had so much to tell, that he came within two pages of the end before reaching the *Amphipoda*. "Chapters," the author tells us, "describing the Gammaridea, the Caprellidea, and the Hyperidea, had already been written, when it appeared that they overflowed the utmost space that could be allowed. As room for them could only be found by an unsatisfactory curtailment of the earlier portions of the work,

I have preferred to leave over this last section of the Malacostraca hoping to engage the reader's interest in it at no distant future."

We earnestly trust this aspiration may speedily be realized, for it may not be known to all who take up Mr. Stebbing's volume, that this group—which Jonah-like, he has had to cast overboard at the last moment, at the command of an inexorable publisher, and a procrustean (*International*) rule as to size!—is the particular section of the Crustacea upon which the author himself has expended almost a life's work, and with a monograph on which he has filled three large volumes of the "Challenger Reports," covering 1774 pages of text 4to. and 212 4to. plates; a task which has occupied him almost exclusively for six years, and the figures for which, like those of the present little work, were all *drawn with his own hands!*

Seeing this is so, and that the *Entomostraca*, the *Merostomata*, the *Trilobita*, and the *Anchoracephala* or *Cirripedia* also remain to be described, it is not too much to hope, that the publishers should speedily give us another companion volume to complete the history of this important group.

The Crabs, *Brachyura*, or "Short-tails," represent the highest development of the Crustacean type existing at the present day; that is to say, if we regard what Dana calls "cephalization," or the concentration of nerves and locomotory organs around a common centre, as the height of perfection in this class.

Crabs with short-tails date back in geological time to the Great Oolite (*Prosopon mammillatum* and *Palæinachus longipes*, H. Woodw., being the oldest known forms). They are frequently met with fossil from the Upper Secondary to the present day, when they attain their maximum within the warmer latitudes, being represented by land, freshwater and marine forms in great variety and abundance. Mr. Stebbing devotes about 100 pages to this first section and gives us pictures of some of the more interesting forms.

The author places the Anomoura or Anomala (Hermit Crabs, etc.) at the commencement of the Macroura (Lobsters), but as has been pointed out by Dr. Woodward (Encyclop. Brit. 1877, 9th edition, vol. vi. p. 656), some Anomoura appear to belong to the Brachyura, or short-tailed division (Crabs), as *Lithodes*, *Porcellana*, *Dromia*, *Dorippe*, etc.—whilst others, as *Galathea*, *Munida*, *Paguri*, and *Birgus* favour the long-tailed Macroura (Lobsters). Obviously then the Anomala belong to both Brachyurous and Macrourous types, from which they diverge by reason of some method of concealment which they have adopted, and which has modified the usual and normal structures of the class to which they belong, just as the Cirripedia (in their adult sedentary state) and the numerous parasitic Isopods, Copepods, and Rhizocephala, are modified until all trace of their Crustacean lineaments is lost. As might reasonably be expected, the Macroura, being less highly specialized than the Brachyura, date back much earlier in time, numerous forms referable to the genus *Anthrapalæmon* having been described by Salter, Woodward, Etheridge, and Peach, from the English and Scottish

Coal-measures. Lobsters are well represented by numerous genera and species from the Trias to the present day, when they are found all over the world, both in Freshwater and Salt. Many of the Oolitic forms of *Eryma* must be *closely* related to the living Cray-fish (*Astacus fluviatilis*) of our own rivers and brooks; whilst the Chalk *Clytia Sussexiensis* with its spiny carapace and body-segments is probably represented to-day by the living spiny Australian Crayfish (*Astacus armatus*) of the Murray River.

Of the Schizopoda, one form, *Pygocephalus Cooperi*, from the Coal-measures, probably belongs to this division. *Squilla* may even occur in the Carboniferous formation; but true Squillas certainly are met with in the Solenhofen Limestone, Bavaria, and in the Cretaceous of the Lebanon, Syria.

Passing over the Cumaceæ, we come next to the Isopoda, a group of great importance and vast extent.

In individuals as well as in species the Isopoda may be counted by myriads, and they occupy as scavengers, along with the Amphipoda, a most important place in the economy of nature whether by land or sea.

Isopods occur as far back in time as the Devonian, and they are well represented in Secondary and Tertiary rocks.

If Dr. Woodward is correct in his conjecture that the Isopoda are the modern modified descendants of the ancient Trilobites, for which there is a considerable amount of evidence, then the Isopoda date back their ancestry to Cambrian times, the Trilobita living on to the Carboniferous period.

The Amphipoda so numerous at the present day all the world over, both in freshwater and salt, are comparatively rare as fossils. One form, *Necrogammarus Salweyi*, occurs as far back as the Upper Silurian; *Gampsonyx* is found in the Coal-measures; *Prosoponiscus* in the Permian, and there are several others in Secondary and Tertiary rocks.

But our space, like Mr. Stebbing's, is limited, and we must say adieu to the author, merely observing, that so useful a book as he has produced, *needs*, like good wine, *no bush* to make it attractive. It should form a part of every scientific and reference library, and as it is one of the volumes of the "International Scientific Series," it will go, as a matter of course, far and wide, and find itself in many distant libraries all the world over. It will occupy an honourable place alongside Prof. Huxley's "Cray-fish," and will we trust, become converted, by a happy conjunction of activity on the part of the author and publishers—like one of the *Desmidiaceæ*—into a pair of volumes before another eighteen months has passed away.

II.—Sur le *Cybium* (*Enchodus*) *Bleekeri* du Terrain Bruxellien. By Raymond Storms. Bull. Soc. Belge Géol. Paléont. Hydrol. Vol. VI. (1892), pp. 3–14, Pl. I.

A WELL-PRESERVED cranium of the Scombroid fish, *Cybium*, was discovered last year by M. Vincent in the Bruxellian formation at Fonteny, near Gemappes, and this forms the subject of

Mr. Storms' memoir, just received. Many years ago teeth from the same formation were described by Dr. T. C. Winkler under the name of *Enchodus Bleekeri*, but further studies led to the belief in 1891 [1] that these fossils were wrongly determined, and would probably prove to belong to the existing genus *Cybium*. The discovery of a new specimen now enables Mr. Storms not only to confirm this revision, but to discuss the affinities of the species. The detailed description of the skull is illustrated by a large, folding plate; and the memoir concludes with a brief synopsis of the known extinct species of *Cybium*. The genus has been discovered in the Eocene of Monte Bolca and the Isle of Sheppey; in the Oligocene of Hesse Darmstadt, in Belgium, and Vienna; and in the Lower Miocene of Chiavon, Italy. *Cybium Bleekeri* must have attained a length of more than a metre, almost equalling in size the existing *C. Commersoni*. Species of the genus are rarely met with in European seas at the present day, its habitat being the warmer regions of the ocean.

A. S. W.

III.—Cavern Researches.

1. Die Irpfelhöle im Brenzthale (Württemberg). By Dr. Eberhard Fraas. Zeitschr. deutsch. geol. Gesell. 1893, pp. 1–14 (reprint).
2. Le Repaire de Roc-Traucat (Ariège), et Notes sur des Mégacéros, Castors, Hyènes, Saigas, et divers Rongeurs Quaternaires du sud-ouest de la France; avec Observations sur le Climat de cette Région à la Fin du Quaternaire. By E. Harlé. Comptes Rendus Soc. d'Hist. Nat. Toulouse, 1892 (1893), pp. 1–18 (reprint).

THE caverns of France and Germany are still receiving attention, and the two small pamphlets quoted above make interesting contributions to our knowledge of the Pleistocene fauna discovered in them. After describing the situation and physical characters of the Irpfel cavern in the valley of the Brenz, Dr. Fraas discusses the remains met with in the cave-earth, recording the occurrence of *Hyæna spelæa, Ursus spelæus, Felis spelæa, Canis lupus* var. *spelæus, Canis vulpes, Elephas primigenius, Rhinoceros tichorhinus, Equus caballus, E. asinus, Cervus tarandus, C. giganteus, C. elaphus, Bos priscus, Castor fiber*, bird remains, *Esox*, and flint flakes. Measurements are given of a nearly complete skull of *Hyæna*—the first discovery of the kind in Würtemberg. Two small Bear's teeth are noted as possibly referable to *Ursus tarandus*, Fraas (=*U. arctoides*, Bl.); and the determination of *E. asinus* is based upon some very small teeth and a metatarsus. Coprolites are abundant, and the cavern was evidently at one period a Hyæna den. Dr. Fraas concludes that there can be no longer any doubt as to the contemporaneity in Würtemberg of Man and the Reindeer with the Mammoth, Rhinoceros, Cave Hyæna, and other animals he has discovered.

[1] Smith Woodward, Geol. Mag. [3] Vol. VIII. p. 109.

Monsieur Harlé's paper on the cavern and other Pleistocene deposits in south-west France, comprises several short notes read at different dates. The Megaceros (*Cervus giganteus*) is recorded from many localities, but merely on the evidence of jaws, no antlers having been observed. The Beaver only occurs rarely, and very few remains are earlier than the "Magdalenian" period. The common Cave Hyæna is met with abundantly; but M. Harlé has been unable to recognize the Striped Hyæna. Remains of the Saiga Antelope are known from twelve localities. The rodents comprise lemmings, marmots, and *Alactaga jaculus*, Pall. — typical steppe-animals. On the whole, the region north of the Garonne appears to have been a great steppe in the "Solutrian" and "Magdalenian" periods, becoming more humid before the last-named stage of human civilization had passed away. A. S. W.

IV.—Preliminary Notices of the Fossil Bones of Ulloma. [Noticias Preliminares sobre los Huesos Fósiles de Ulloma.] By Dr. R. A. Philippi. Annales de la Universidad de Chile, 1893, pp. 499–506, pls. i.–iii.

THESE are preliminary notes on some Mammalian bones from Ulloma in Bolivia. An equine mandibular ramus is referred to *Hippidion nanum*, Burm., and another is believed to represent a new species of the same genus. The remains of *Mastodon*, *Megatherium*, and *Scelidotherium* (?) are briefly discussed, with three plates of outline figures.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 10th, 1893.[1]—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:

2. "The Llandovery and Associated Rocks of the Neighbourhood of Corwen." By Philip Lake, Esq., M.A., F.G.S., and Theo. T. Groom, Esq., B.Sc., F.G.S.

The area described forms part of the northern slope of the Berwyn Hills, and stretches along the southern bank of the Dee from Corwen to Pen-y-glog. The beds of the Berwyns are here thrown into a series of folds which run nearly E.–W.; and the northerly limbs of these folds are long and low, while the southerly limbs are short and steep. The folds are cut through by a number of faults which run nearly E.–W., generally along the crests of the anticlinals, and these invariably throw down towards the north. The southern bank of the Dee Valley is here formed by these faults.

A second series of faults running about 20° W. of N. to 20° E. of S. is of later date. One of these, near Corwen, presents some peculiar features, since its downthrow in some places is on the east and in others on the west.

The lowest beds present are bluish slates with numerous Bala fossils. These are succeeded immediately by the Corwen Grit of

[1] Continued from the June Number.

Prof. Hughes. No fossils have been found in this at Corwen; but in a grit occupying a similar position at Glyn Ceiriog numerous fossils have been discovered. The Corwen grit is succeeded by grey slates with grit-bands; and in Nant Cawrddu near Corwen, and Nant Llechog near Pen-y-glog, these slates are followed by banded black shales containing numerous graptolites of the *Monograptus gregarius*-zone. Above these are pale bluish slates; and nothing further is exposed till we reach the Tarannons. The Corwen Grit clearly forms the base of the Llandovery in this area, as suggested by Prof. Hughes.

II.—May 24th, 1893.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "Notes on Dartmoor." By Lieut.-General C. A. McMahon, F.G.S.

The author alludes to Part II. of a memoir on the British Culm Measures recently published by Mr. Ussher, F.G.S., in which the view is advanced that the granite of Dartmoor resulted from the metamorphism of pre-existing rocks which had in a rigid state offered obstruction to a long sustained N. and S. squeeze, and that their fusion and consequent consolidation were effected *in situ*.

The author gives some of the results of a visit to the western borders of Dartmoor. He details some examples of eruptive granite-veins intruding into Culm beds in the immediate vicinity of the main mass of granite. The latter, in the locality described, is porphyritic down to its boundary, and the veins are also porphyritic. All the circumstances lead the author to believe that these veins are real apophyses from the main mass, and that the view adopted by De la Beche regarding the origin of the Dartmoor granite is the true one. The author alludes to some features in the Meldon granite-dyke not before noted; gives some detailed observations in the bed of the River Tavey, and offers an explanation of the way he thinks the fine-grained marginal variety of the granite, seen in that locality, has been produced.

The author comments on the improbability that a tremendous squeeze sufficient to fuse 225 square miles of a pre-Devonian rock into granite should have left the Culm Measures outside the zone of marginal contact-metamorphism almost untouched.

The author, in conclusion, alludes to the often-observed pseudo-stratification of the Dartmoor granite, and urges that the cause of this is not the one suggested by De la Beche, but that it is due to sub-aerial agencies.

2. "On some Recent Borings through the Lower Cretaceous Strata in East Lincolnshire." By A. J. Jukes-Browne, Esq., B.A., F.G.S.

The borings described in this paper are at Alford, Willoughby, and Skegness, and disclose the existence of an unsuspected anticlinal axis bringing up Lower Cretaceous rocks beneath the Drift. In the Willoughby boring, beneath the Drift, a brown sand was obtained, apparently the 'Roach' division of the Lower Cretaceous, and below

it the Tealby Clays (108 feet), oolitic ferruginous beds (18 feet), and sandstone and sand regarded as the Spilsby Sandstone. In the Alford boring the highest solid rock appears to belong to the basal beds of the Red Chalk, and below it is Carstone, and then clay.

The axis of the anticlinal appears to pass between Alford and the border of the Wolds, and is probably continued in a north-westerly direction beyond the village of Claythorpe.

The result of the information now obtained makes it probable that the Chalk tract which lies to the south-east of the Calceby valley is completely isolated from the rest of the Chalk area.

III.—The Geologists' Association.

Excursions Around Bath.

The Whitsuntide excursion of the Geologists' Association, London, commenced on Saturday, 20th May, the rendezvous for the present tour being Bath, Bradford-on-Avon, and Westbury. The Members, about thirty-five in number, arrived in the city of Bath from London and were met at the station by the Rev. H. H. Winwood, F.G.S., who accompanied the party through Widcombe to Combe Down. Mr. Horace B. Woodward, F.G.S., H.M.G.S., President of the Association, acted as Director. On the way a small section of the Fuller's Earth formation was examined, while on the top of the hill one of the stone quarries was visited. Here Combe Down stone, a good freestone belonging to the Bath or Great Oolite, so celebrated in the district, was seen to advantage. The President remarked on the variability of the stone-beds, both in thickness and character as they are traced from one locality to another. In most places the freestone was mined, but here at Combe Down a very durable stone was obtained in open works. Passing on towards Midford, a halt was made at Tucking Mill, once the residence of William Smith, "the Father of English Geology," who was engaged in the construction of the Somersetshire Coal Canal. Through the kindness of Mr. Garrett the Midford Fuller's Earth Works were then examined, and the various processes which the earth undergoes before it becomes marketable were explained. The spots where the earth was dug were next visited, and some fossils were obtained from the hard nodules of earthy limestone that occur in the Fuller's-Earth-clay. The economic Fuller's Earth is an unctuous clay, but it is not plastic like ordinary clay, falling to a powder under water. It owes its peculiar detergent properties to its physical characters rather than to any ingredients it contains; but its particular mode of origin remains to be explained. A number of Ostracoda (tiny bivalved Crustacea) have been found in it. From these works the members proceeded to the road-cutting, south of Midford railway station, and there saw a good section of the Inferior Oolite and underlying Midford Sands. The President pointed out that the Inferior Oolite represented only the upper part of that formation, characterised by *Ammonites Parkinsoni* and *Rhynchonella spinosa*. Many examples of *Trigonia*, *Ryhnchonella*, and some Corals were

obtained. Mr. Winwood pointed out that the lowest bed of the Inferior Oolite contained pebbles of limestone; and this suggested some reconstruction of the strata that marked the interval between the Inferior Oolite and the Midford Sands at this locality. The Midford Sands represented the passage-beds between the Upper Lias and the lower beds of the Inferior Oolite: they yielded *Ammonites radians*, *A. striatulus*, etc. The members returned to Bath by the 5.37 train.

After dinner at the Fernley Hotel, the President drew attention to some of the geologists who have made Bath famous. He first mentioned John Walcott, whose "Descriptions and Figures of Petrifactions, found in the quarries, gravel-pits, etc., near Bath," was published more than 100 years ago, in 1779. William Smith too was more intimately acquainted with Somersetshire (perhaps Yorkshire excepted) than with any other part of England, and for some time he had resided at Bath. One of his friends, the Rev. Joseph Townsend, rector of Pewsey, had in 1813 first published some of Smith's facts, including accounts of our Oolitic strata and their fossils. Townsend's work was entitled "The Character of Moses established for veracity as an Historian, recording events from the Creation to the Deluge," and the title had naturally somewhat obscured the geological merits of the work. The Rev. J. J. Conybeare, for 11 years rector of Batheaston, was also mentioned, for he did some good geological work, and introduced Sedgwick to his brother, the distinguished W. D. Conybeare, who at one time held a lectureship in the church at Brislington. Talking of Sedgwick called to mind the fact that one of his earliest pupils at Cambridge was the Rev. Leonard Blomefield (then Jenyns)—a man distinguished as a Zoologist, and who also had rendered service to Geology. He attended Sedgwick's lectures so long ago as 1819-20, and had remarked that even then, a year after he had been elected, the Professor "seemed a master of the subject." Passing on to William Lonsdale, some account of his early life was given. He was born in Bath in 1794 and served in the Peninsular War. He was the founder of the Bath Geological Museum and was Honorary Curator from 1826 to 1829, when he went to London. His geological work was referred to as an example of careful and accurate study, and one of his MS. geological maps was exhibited. Mr. Winwood also brought some of his MS. catalogues, which are marvels of neatness. Remarks were also made on Charles Moore, who did so much to elucidate the geology of Somerset, and whose collections of fossils from the Lias and Oolites form so important a feature in the Bath Museum.

On Monday the members of the Association visited Bradford-on-Avon, leaving Bath at 10.18 a.m. There were about 60 members and friends, including Mr. W. H. Hudleston, F.R.S., President of the Geological Society of London), and Mrs. Hudleston, Prof. J. F. Blake and Prof. Lloyd Morgan. The first portion of the programme was under the direction of the Rev. H. H. Winwood, and he conducted the party to the pits by the canal on the south side of

Bradford. There the Great Oolite is overlaid by the Bradford Clay, which at its base contains a rich fossil bed. Among the fossils the most noteworthy were the Bradford Encrinites, portions of which were familiarly known as "Pegtops" and "Coach wheels"—this is an old stone lily. Many Brachiopoda were found, such as *Waldheimia digona* and various *Rhynchonellæ*, also the characteristic *Terebratula coarctata*. Some members of the party went underground in one of the quarries to see the working of the freestone. Other quarries were visited at Ancliffe, and then a general halt was made at the "Three Guns." Proceeding along the north side of the canal, one Norris, a veritable cave-dweller, was visited. This descendant of Palæolithic man dwells in a hollow excavated in the Inferior Oolite, and he devotes himself to the manufacture of eel-baskets, whereby he contrives to support himself, and pay his rent of 1*s.* a year. The party was then conducted to the Winsley quarry, and there Mr. W. H. Wickes took the direction.

After a delightful though warm walk up and down hill the members reached the old quarry of Muirhill, where a rich treat awaited them in the shape of Corals, Polyzoa, and tiny Gasteropoda. The quarry was worked some 70 years ago but has long been abandoned. The fossil beds lie above the freestone, and tumbled masses of the rocks strew the old floor of the quarry. The examination of the place completed the programme. The members then proceeded to Limpley Stoke for tea, before returning to Bath. On the way Mr. Winwood drew attention to the occurrence of the Musk-Ox (*Ovibos moschatus*) in the valley gravel at Freshford, and Mr. H. B. Woodward (president), Professor Lloyd Morgan and Professor Blake made some remarks on the formation of the valley.

On Tuesday morning the members left Bath for Westbury, in Wiltshire, the President, Mr. H. B. Woodward, taking the direction of the party. Fortunately, Mr. Hudleston, F.R.S., was present; and, on arriving at the Westbury Station, Mr. J. R. Tennear, secretary of the Westbury Iron Company, guided the members through the works and explained the processes which the iron-ore undergoes before conversion into pig-iron. The iron-ore occurs at the top of the Corallian beds, and is overlain by the Kimmeridge clay. It is on the same horizon as the ironstone of Abbotsbury, in Dorsetshire. Several fine Ammonites and large numbers of *Ostrea deltoidea* and other fossils were obtained from this ferruginous rock. A fine section of the beds beneath the ironstone was also exposed. This showed a few feet of sand, and then rubbly oolitic and marly beds with *Ammonites plicatilis;* also *Pseudomelania*, *Bourguetia* (*Phasianella*), and other Gasteropods; *Echinobrissus scutatus*, and a few corals. It was pointed out that this bed probably corresponded with the famous Coral-bed of Steeple-Ashton. Beneath these rubbly beds there was a fine section of false-bedded oolite, quarried for use as a flux in the furnaces. At two o'clock the members witnessed the interesting sight of the flow of the molten iron from one of the blast-furnaces, the fiery stream running in channels or moulds in sand where it solidifies in the form of "pig-iron."

Being detained at the railway station Mr. Hudleston gave some account of the origin of the iron-ore. He pointed out that the occurrence of the large oysters, pectens, and limas, accounted for the presence of phosphoric acid by the decomposition of the animal-matter in those Mollusca. The iron-salts had been introduced into the rocks subsequent to their deposition, and he thought that the decay of fossil wood had been an important factor in the formation of organic acids which had helped to form the carbonate of iron. The iron-carbonate characterised the grey beds that were covered up by the Kimmeridge clay, while the reddish-brown ironstone at the outcrop had subsequently been "rusted." The lower Corallian beds showed little or no signs of ferruginous infiltrations, therefore he thought we must look to the overlying beds for the immediate source of the iron-ore. The members visited other sections in the ironstone; and afterwards walked to the Eden Vale brickyard, where the Gault clay is dug for the manufacture of bricks. The proceedings terminated with an excellent tea at the Lopes Arms at Westbury.—"The Bath Herald." May 27, 1893.

IV.—Glasgow Geological Society.

May 25, 1893.—Mr. Dugald Bell, F.G.S., read the third of a series of papers on "The Alleged Proofs of Submergence in Britain during the Glacial Epoch." In this he treated of the "shell-beds" or shelly-clays in the north of Scotland, at Clava, near Inverness (500 feet O.D.), and on the eastern coast of Aberdeenshire (200 to 300 feet, with gravels considerably higher). Without anticipating the results of the examination of the Clava beds, now in progress by a Committee of the British Association, he was free to state the considerations, founded on what was known a year ago, from which it appeared doubtful whether this clay were really in place, as part of an ancient sea-bottom. All the difficulties which were enumerated in a former paper with regard to Chapelhall, seemed to apply to this bed at Clava also, and some with even greater force. There was the absence of all traces of the sea at a similar level, and at innumerable subordinate levels, over the district generally, and particularly in the numerous side-glens, where such traces would be most likely to accumulate and be preserved. There was the inadequacy of the cause usually assigned for this absence, viz. a "second glaciation," which, if granted, might account for it in some localities, but not in all. To suppose that the ice removed all traces of the sea at such levels over the country generally, was to credit it with far more than ordinary glacialists required of it. Besides, it was cutting away the very ground on which advocates of a "deep submergence" rested. For if this supposed "second glaciation" wrought such havoc among the evidences of the former presence of the sea at such levels over the whole country, where was the certainty that any marine remains now found anywhere at such levels were really in place? They may have been shifted to almost any extent by ice that could do so much. Lastly, there was the remarkable

absence of marine organisms, or any traces of them, over the country generally, in the "Upper Boulder-clay," said to have been the product of this "post-submergence glaciation," when the ice must have passed over hundreds of square miles of former sea-bottom. These and similiar difficulties led to the consideration of the hypothesis that the shells, or masses of shelly clay, may have been transported inland from a former sea-bed by the ice, as in many instances which had been proved and were well known. The ice-blocked condition of the North Sea, during the Glacial period, had been demonstrated by Messrs Peach and Horne and the late Dr. Croll, in their admirable papers on the "shelly till" of Caithness. This, combined with the pressure of ice from the adjacent mountainous region of Inverness and Ross-shires, forced the great ice-stream issuing from Loch Ness to turn eastwards, and to some extent upwards, along the base of the hills to the south of Inverness, in the direction of Forres and Elgin. The striæ and the distribution of boulders over the district abundantly proved this; and it was also clear that the ice must have passed over part of the former sea-bed in its progress. Other evidences from that part of the country of the transport inland of materials from the sea-bottom (as fragments of chalk, the limestone near Elgin, etc.) were alluded to; and the author held that, on the whole, till clear proof be obtained, doubts were justified as to this shelly-clay at Clava being really in place. In the concluding part of his paper the author referred to the "red clay," with a few fragments of shells, described by Mr. Jamieson, of Ellon, as occurring in hollows and patches along the north-east of Aberdeenshire up to about 300 feet.[1] For reasons similar and additional to those already stated, he thought this clay could not be accepted as a satisfactory proof of submergence. It could be accounted for by the agencies which Mr. Jamieson had indicated, without submergence; and indeed, its characteristics seemed to be, in several respects, opposed to that theory.

CORRESPONDENCE.

"THE TRUE HORIZON OF THE MAMMOTH."

Sir,—As Sir Henry Howorth asks me to explain some of the remarks that I ventured to make against the cogency of his *foreign* evidence in favour of the pre-Glacial age of the Mammoth, I may premise, contrary to Sir Henry's assumption of my *recent* acquaintance with the subject under discussion, that I have long taken an interest in the many problems that surround the question of the Mammoth and its times, and think that I have read, not without interest and appreciation, most of Sir Henry's writings on this matter, but I must say that the reading has not always brought me to the same conclusions as the author.

I have no pre-conceived views to support and endeavour to bear an open mind on the subject, and most certainly I had no idea of indulging in the dogmatism with which I am charged, for in

[1] Quar. Jour. Geol. Soc. vol. xxxviii.

my innocence, I thought that burden lay heavily on Sir Henry's shoulders.

Now to the argument,—first comes the evidence of the Lignite beds at Dürnten and Utznach, in which Sir Henry says he cannot quite follow me when I referred to the difficulties of proving the age of the beds by their contained animal remains, consisting of an association and mixture of pre-Glacial and post-Glacial forms of extinct and living species, which can scarcely have been contemporaneous.

Doubtless, the stratigraphical position and assumed age of these Zurich beds was determined by their fossil contents, but the evidence does not appear to me conclusive on this point, and certainly Sir Chas. Lyell speaks much more guardedly than Sir Henry, and Heer himself does not claim a pre-Glacial antiquity for the Mammoth. Professor Heer, summarising the evidence on this question, says (*vide* Heer's Primeval World of Switzerland, Vol. II, p. 217, English Edition), "From the facts hitherto ascertained we learn that the Mammoth appeared in Switzerland at the *end* of the *second* glacial epoch" (the italics are mine).

Moreover, in the Professor's Chronological Table of the Quaternary Period (*op. cit.* p. 203) the true horizon of the Mammoth is evidently undetermined by him, as a point of interrogation is affixed to its first appearance.

Turning now to Sir H. Howorth's strictures on the Russian evidence which I adduced as opposed to his reasoning, and the relevancy of which he says he cannot understand, possibly so, seeing that he is apparently referring to a quite different expedition to the one I cited. The Bear Islands expedition, of which he speaks with that fulness of knowledge so characteristic of him, I never mentioned, as I had no facts before me with regard to it bearing on the question at issue.

If Sir Henry will refer to my paper he will see that it was an expedition to the New Siberian or Liakov Islands of which I was speaking, and which are separated from the Bear Islands by three or four degrees of longitude.

The results of that expedition, so far as regards the Mammoth problem, is only known to the general public through M. Schmidt's brief analysis of Baron Toll's book to which I referred, and which has apparently been ignored by Sir Henry Howorth. Is it too much to ask of Sir Henry to read what he is supposed to be replying to, before indulging in somewhat acrid criticism?

I have a letter from M. Schmidt, who is a member of the Academy of Sciences of St. Petersburg and a foreign correspondent of the London Geological Society, dated in the early part of February last, in which he says Baron Toll's book is not yet fully printed, and that the Baron has left St. Petersburg on another Mammoth quest and will probably be absent about a year.

It is from special explorations such as those of Baron Toll in the so-called "Home of the Mammoth" that its true horizon, so far at least as its Asiatic home, is to be predicated.